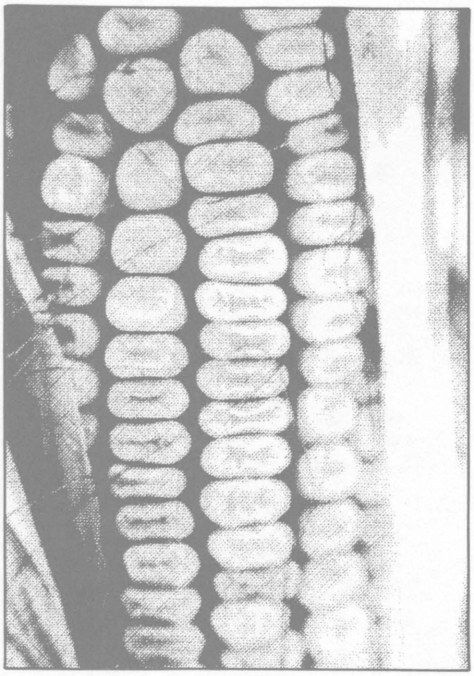
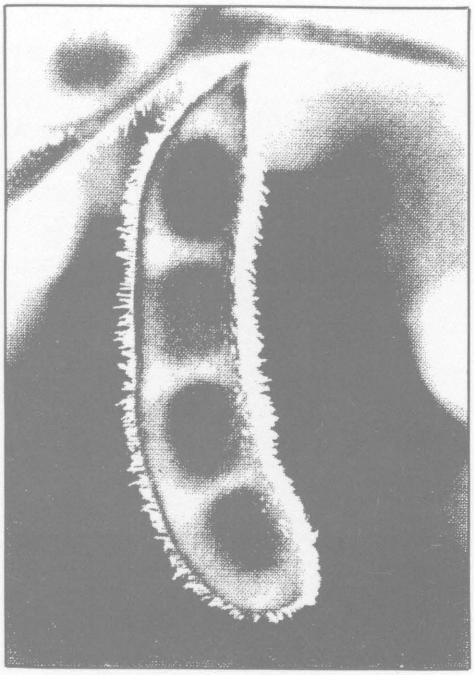




Illinois Agronomy Handbook 1981-82

Circular 1186

University of Illinois at Urbana-Champaign
College of Agriculture
Cooperative Extension Service

CONTENTS

This publication was prepared by L.V. Boone, D.W. Graffis, R.G. Hoeft, E.L. Knake, M.D. McGlammery, M.R. Owen, T.R. Peck, G.E. Pepper, R.A. Pope, W.O. Scott, M.D. Thorne, and L.F. Welch, all of the Department of Agronomy, E.R. Jaycox of the Department of Horticulture, and J.C. Siemens of the Department of Agricultural Engineering. Contributions also were made by George McKibben, Dixon Springs Agricultural Center, and George Kapusta, Southern Illinois University, as well as by the Departments of Plant Pathology and Horticulture, and the Economic Entomology Section of the Illinois State Natural History Survey.

Urbana, Illinois — This replaces Circular 1165 — December, 1980

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. WILLIAM R. OSCHWALD, *Director*, Cooperative Extension Service, University of Illinois at Urbana-Champaign. The Illinois Cooperative Extension Service provides equal opportunities in programs and employment.

20M—12-80—49322—SZ

Hybrid Selection

One of the most important decisions a corn producer makes every year is which hybrids he should grow. Since yield differences of 20 to 30 bushels per acre are not uncommon, the decision must be carefully made. Maturity, lodging resistance, disease resistance, and average yield should all be considered.

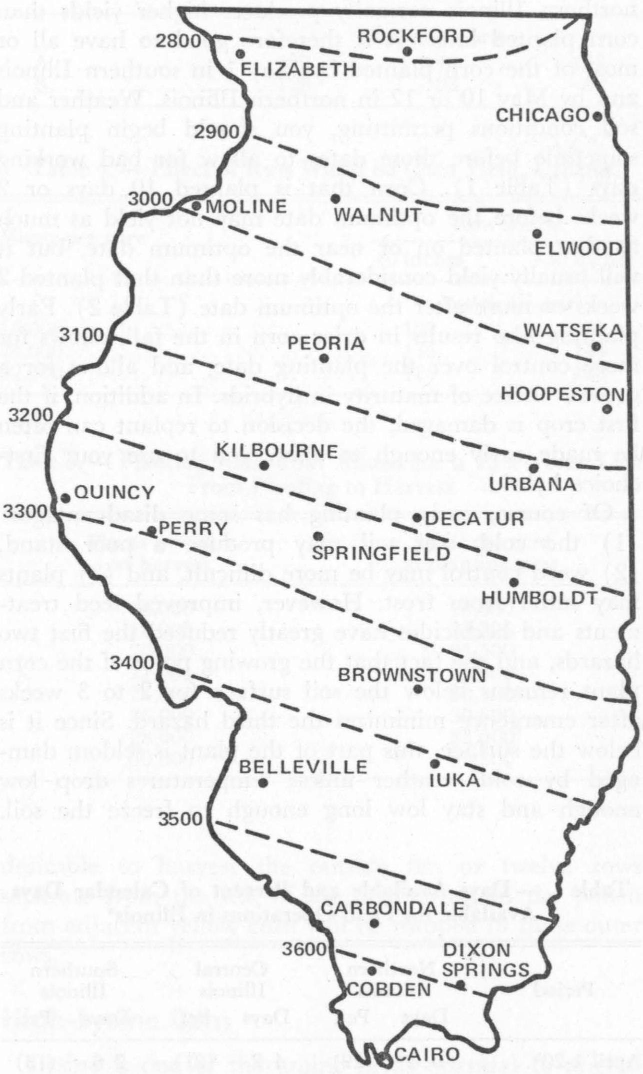
Hybrids that use most of the growing season to mature usually produce higher yields than those that mature more quickly — unless, of course, they are grown in an area with too short a growing season. For best results, the latest-maturing hybrid chosen should reach maturity at least two weeks before the average date of the first killing freeze (32° F.). Physiological maturity has been reached when kernel moisture is 30 to 35 percent and when the black layer caused by cell collapse is visible near the tip of the kernel. This layer first appears on the kernels at the tip of the ear and finally moves to the butt of the ear.

It is good to select hybrids that will mature at different times. This practice stretches the work load at harvesttime and in some years may reduce harvest losses by permitting more timely harvesting. It may also reduce stress at pollination time.

Information concerning hybrids is available from several sources. The Department of Agronomy conducts hybrid tests each year at 11 locations in Illinois, the results of which are published annually in the Illinois Cooperative Extension circular, *Performance of Commercial Corn Hybrids in Illinois*. The 11 locations represent the major soil and climatic areas of Illinois. The circular gives data on average yield, kernel moisture, percentage of erect plants, and population of hybrids tested in each location. Other sources of information are your own tests and tests conducted by seed companies, neighbors, county Extension personnel, and vocational agricultural classes.

You should see the results of as many tests as possible before choosing a hybrid. Good performance for more than one year is one important criterion. You should not base your decision on the results of only one "strip test." These tests use only one strip of each hybrid; the difference between two hybrids may therefore be due to location in the field rather than to an actual superiority of one over the other.

Comparing hybrid maturities is sometimes difficult, especially because seed companies label hybrids in different ways. Some companies indicate the number of days to maturity, some indicate the growing degree days, and some indicate both. See Figure 1 for the average number of growing degree days accumulated from May 1 through September 30 for the period 1941-1970. To calculate growing degree days, add the maximum temperature and the minimum temperature, divide the sum by 2, and then subtract 50. If the maximum temperature is higher than 86° F., substitute 86° F. for the actual temperature. If the minimum temperature is below 50° F., use 50° F. as the minimum. According to this system, corn should be mature when the total number of growing degree days accumulated after planting equals the number of growing degree days specified by the seed company as necessary to reach maturity. You can also compare maturity among hybrids by comparing kernel moisture levels as reported in the Illinois Cooperative Extension circular previously mentioned.



Average number of growing degree days, May 1 through September 30, based on temperature data provided by the U.S. Department of Commerce, National Weather Service, 1941-1970. (Fig. 1)

The only source of information on the disease resistance of different hybrids is the seed corn salesman. Information on stalk strength and comparative yields can be obtained from your salesman or from data on percentage of erect plants and corn yields as reported in *Performance of Commercial Corn Hybrids in Illinois*. The section near the beginning on comparing hybrids is especially helpful.

Planting Date

Long-term studies in Illinois show that corn planted by May 1 in southern Illinois and by May 10-15 in northern Illinois normally produces higher yields than corn planted later. It is therefore good to have all or most of the corn planted by May 1 in southern Illinois and by May 10 or 12 in northern Illinois. Weather and soil conditions permitting, you should begin planting sometime before those dates to allow for bad working days (Table 1). Corn that is planted 10 days or 2 weeks before the optimum date may not yield as much as that planted on or near the optimum date, but it will usually yield considerably more than that planted 2 weeks or more after the optimum date (Table 2). Early planting also results in drier corn in the fall, allows for more control over the planting date, and allows for a greater choice of maturity in hybrids. In addition, if the first crop is damaged, the decision to replant can often be made early enough to allow you to use your first-choice hybrid.

Of course, early planting has some disadvantages: (1) the cold, wet soil may produce a poor stand, (2) weed control may be more difficult, and (3) plants may suffer from frost. However, improved seed treatments and herbicides have greatly reduced the first two hazards, and the fact that the growing point of the corn plant remains below the soil surface for 2 to 3 weeks after emergence minimizes the third hazard. Since it is below the surface, this part of the plant is seldom damaged by cold weather unless temperatures drop low enough and stay low long enough to freeze the soil.

Table 1. — Days Available and Percent of Calendar Days Available for Field Operations in Illinois[a]

Period	Northern Illinois		Central Illinois		Southern Illinois	
	Days	Pct.	Days	Pct.	Days	Pct.
April 1-20[b]	5.8	(29)	4.2	(21)	2.6	(13)
April 21-30[c]	3.5	(35)	3.1	(31)	2.6	(26)
May 1-10[c]	5.8	(58)	4.3	(43)	3.5	(35)
May 11-20[c]	5.5	(55)	5.0	(50)	4.4	(44)
May 21-30[c]	7.4	(74)	5.8	(58)	5.4	(54)
May 31-June 9[c]	6.0	(60)	5.4	(54)	5.6	(56)
June 10-19[c]	6.0	(60)	5.4	(54)	5.8	(58)

[a] Summary prepared by R. A. Hinton, Department of Agricultural Economics of the University of Illinois Cooperative Crop Reporting Service, unpublished official estimates of Favorable Work Day, 1955-1975. The summary is the mean of favorable days omitting Sundays, less one standard error, representing the days available 5 years out of 6.
[b] 20 days.
[c] 10 days.

Table 2. — Effect of Planting Date on Yield[a]

	Northern Illinois	Central Illinois	Southern Illinois
Late April	...	156	102
Early May	151	162	105
Mid May	150	...	82
Early June	100	133	58

[a] 3-year average at each location.

Even when corn is frosted, therefore, the probability of regrowth is excellent. For these reasons, the advantages of early planting are felt to outweigh the disadvantages.

The lowest temperature at which corn will germinate is about 50° F. Therefore, planting may begin when the soil temperature at planting depth is 50° F. or higher. The five-day weather forecast also should be favorable. You probably will need to determine soil temperature on your own because soil temperatures reported by weather bureaus usually are taken under sod. The mid-day temperature at 2 to 4 inches under sod often is 8 to 12 degrees lower than it is under bare ground.

The following guides may be helpful:

1. Plant when the temperature at 7 a.m. reaches 50° F. at the 2-inch level. This will assure a favorable temperature for growth during most of a 24-hour period if there is an appreciable amount of sunshine.
2. Plant when the temperature at 1 p.m. reaches 55° F. at the 4-inch level. The 4-inch level is suggested for the 1 p.m. measurement because this level is not affected as much as the 2-inch level by a single day of bright sunshine.

After May 1, plant if the soil is dry enough even if the soil temperature is below the suggested guidelines. Perhaps a simple way to say it is plant according to soil temperature early in the season, later on plant by the calendar.

Some areas, such as river bottoms and low-lying flatlands, tend to warm up slowly and are subject to late freezes. These areas should be the last to be planted.

When planting in April, plant the full-season hybrids first and be sure of your weed control program. You also may consider increasing your planting rate 1,000 to 2,000 kernels per acre because the early planted corn is normally shorter and is less likely to be under moisture stress when pollinating.

Planting Depth

Ideal planting depth varies with soil and weather conditions. Emergence will be more rapid from relatively shallow-planted corn; therefore, early planting should not be as deep as later planting. An ideal depth for normal conditions is about 2 inches. Early planted corn should not be any deeper than that; up to ½ inch shallower is preferred. Later in the season when temperatures are higher and evaporation is greater, planting 1 inch deeper to reach moist soil may be advantageous.

Depth-of-planting studies show that not only do fewer plants emerge when planted deep, but also that those that do emerge often take longer to reach the pollinating stage and may have higher moisture in the fall.

Plant Population

Your goal at planting time is the highest population per acre that can be supported with normal rainfall without excessive lodging, barren plants, or pollination problems. How do you know when you have found the ideal or optimum population for a particular field? Check the field after the crop is mature for average ear weight. Most studies in Illinois show that there is a very close relationship between half-pound ears and optimum population. A half-pound ear should shell out 0.4 of a pound of grain at 15.5 percent moisture. The optimum population for a particular field is influenced by several factors, some of which you can control and some over which you have little or no control. Concentrate on those factors that you can control. For instance, there is little that you can do to affect the amount of water available to the crop during the growing season. This variable is determined by the soil type and the total amount and distribution of the rainfall between the time the crop is planted and when it is mature. But there is much that you can do about how efficiently this water is used. The more efficient its use, the higher the population that can be supported with the water that is available. Remember that ear number is generally more important than ear size, and that the most practical way to increase ear number with today's hybrids is through population control.

Two very important factors influencing the efficiency of water use that you can control are soil fertility and weeds. Keep the fertility level of your soil high and the weed population low.

Other factors that are important include:

1. **Hybrid selection.** Hybrids differ in their tolerance to the stress of high populations (Table 3).

2. **Planting date.** Early planting enables the plant to produce more of its vegetative growth during the long days of summer and to finish pollinating before the normal hot, dry weather in late July and early August.

3. **Row width** (Table 4).

4. **Insect and disease control.**

The harvest population is always less than the number of seeds planted. Insects, diseases, adverse soil conditions, and other hazards take their toll. You can expect from 10 to 20 percent less plants at harvest than seeds planted (Table 5).

White Corn

Most of the white corn grown in the United States is used to make corn flakes and cornmeal. It often sells at a higher price than yellow corn, sometimes as much as 1½ to 2 times the price of yellow corn.

The cultural practices for producing white corn are the same as those for yellow corn except that there are relatively few white hybrids available in maturities adapted to Illinois. Choice of hybrid is therefore important. In addition, kernels developed from ovaries pollinated by pollen from yellow hybrids will be light yellow. These yellowish kernels are undesirable. The official standards for corn specify that white corn not contain more than 2 percent of corn of other colors. Therefore, white corn probably should not be planted on land that produced yellow corn the year before. It also may be desirable to harvest the outside ten or twelve rows separate from the rest of the field. Most of the pollen from adjacent yellow corn will be trapped in those outer rows.

Table 3. — Effect of Crowding on Corn Yield, Urbana

Variety	Plants per acre planted in 30-inch rows		
	16,000	24,000	32,000
	Bushels per acre		
A	127	140	153
B	126	98	62

Table 4. — Effect of Row Width on Corn Yield, Urbana

Plants per acre	Row width	
	40 inches	30 inches
	Bushels per acre	
16,000	127	132
24,000	133	144
32,000	126	138

Table 5. — Planting Rate That Allows for a 15 Percent Loss From Planting to Harvest

Plants per acre at harvest	Seeds per acre at planting time
16,000	18,800
18,000	21,200
20,000	23,500
22,000	25,900
24,000	28,200
26,000	30,600
28,000	33,000
30,000	35,300

High-Lysine Corn

Lysine is one of the amino acids essential to animal life. Livestock producers need not be concerned whether the protein that ruminant animals eat contains this amino acid because the microflora in rumen can synthesize lysine from lysine-deficient protein. Nonruminants cannot do this, however, so swine, poultry, and humans must have a source of protein that contains sufficient lysine to meet their needs.

Normal dent corn is deficient in lysine. The discovery in 1964 that the level of this essential amino acid was controlled genetically and could be increased by incorporating a gene called Opaque 2 was exciting news to the corn geneticist and the animal nutritionist.

The potential value of this discovery to the swine farmer was obvious when feeding trials demonstrated that substantially less soybean meal was required when high lysine corn was fed to swine.

Agronomic research with high-lysine corn indicates that it is slightly lower in yield and higher in moisture than its normal counterpart. Furthermore, the kernel is softer and more susceptible to damage. Current research with more sophisticated hybrids, however, indicates that the differentials in yield may be overcome; continued work probably will solve the other problems.

The Opaque 2 gene is recessive: high-lysine corn pollinated by normal pollen produces normal low-lysine grain. Although isolation from normal corn is not essential, regular hybrids, for example, should not be strip planted in high-lysine corn, nor should high-lysine be planted where volunteer normal corn is expected to be high.

Lysine content may be reported as percent of dry weight or on a No. 2 yellow corn basis. No. 2 yellow corn may contain up to 15.5 percent moisture; thus it is 84.5 percent dry weight. Lysine content reported as percent of dry weight only thus is 15.5 percent higher than the same lysine content reported on a No. 2 yellow corn basis. To convert from a dry matter basis to percent of No. 2 yellow corn, multiply by 84.5 percent.

With the aid of county agricultural extension advisers, 136 high-lysine samples were obtained from 35 Illinois counties during the 1973-74 winter. The percent of lysine, percent of total protein, and percent of contamination from normal corn were determined on a dry-matter basis for each sample. The samples ranged from a low of 0.29 percent lysine to a high of 0.54 percent lysine. The average lysine content of all 136 samples was 0.37 percent. Seventy-seven percent of the variation in lysine content could be accounted for by variation in total protein content and the amount of contamination from normal corn. The sample with the lowest lysine content also had the lowest protein content (7.3 percent). The sample with the highest lysine content had the highest protein content (12.2 percent).

Other Types of Corn

High-oil corn. In the summer of 1896, Dr. C. G. Hopkins of the University of Illinois started breeding corn for high oil content. With the exception of three years during World War II, this research has continued. The oil content of the material that has been under continuous selection has been increased to 17.5 percent from the 4 to 5 percent that is normal for dent corn.

Until recently, yields were disappointing for varieties with higher oil content than normal dent corn. However, recent research involving new gene pools of high-oil material unrelated to the original Illinois High Oil indicates that varieties containing 7 to 8 percent oil may be produced with little or no sacrifice in yield. Experimental higher oil hybrids will probably be marketed soon on a limited scale.

Since oil is higher in energy per pound than starch, a livestock ration containing high-oil corn should have some advantage over one containing normal corn. Feeding trials involving high-oil corn have generally confirmed this assumption. The corn-milling industry's interest in high-oil corn as a source of edible oil is increasing. Corn oil has a high ratio of polyunsaturated fatty acids to saturated fatty acids. It is used in salad oils, margarine, and cooking oils.

Waxy maize. Waxy maize is a type of corn that contains 100 percent amylopectin starch instead of the 75 percent typical for ordinary dent hybrids. Amylopectin starch is used in many food and industrial products.

Our chief source of amylopectin starch prior to World War II was tapioca imported from eastern Asia. The Japanese occupation of what was then the Dutch East Indies essentially cut off our supply of tapioca. An emergency program to develop and produce waxy maize was undertaken by the government. After the war, waxy maize continued to be an important supply of amylopectin starch. Several corn-milling companies annually contracted for its production in the central Corn Belt.

The waxy characteristic is controlled by a recessive gene. Therefore, waxy corn pollinated by pollen from normal corn will develop into normal dent corn. Waxy corn, like high-lysine corn, should not be planted in fields where dent corn is likely to volunteer. The outside six to ten rows also may need to be kept segregated from the rest of the field to keep the amount of contamination from normal corn to an acceptable level.

High-amylose corn. High-amylose corn is corn in which the amylose starch content has been increased to more than 50 percent. Normal corn contains 25 percent amylose starch and 75 percent amylopectin starch.

The amylose starch content also is controlled by a recessive gene. Therefore, isloation of production fields is important, as is selecting production fields that were not in normal corn the previous year.

SOYBEANS

Planting Date

Soybeans should be planted in May. The full-season varieties will yield best when planted in early May. Earlier varieties often yield more when planted in late May than in early May. The loss in yield of the full-season varieties when planting is delayed until late May is minor compared with the penalty for planting corn late. Therefore, the practice of planting soybeans after the corn acreage has been planted is accepted and wise.

The loss in yield of soybeans becomes more severe when planting is delayed past early June. However, the penalty for late-planted corn is proportionally greater and the danger of wet or soft corn becomes such a threat that soybeans are, under many conditions, a better crop for late planting than corn (Tables 6 and 7).

Table 6. — Yields of Soybeans Planted on Four Dates, Urbana

Variety	Date of planting			
	May 7	May 21	June 8	June 19
	Bushels per acre			
Corsoy	56	62	49	42
Beeson	57	55	52	47
Calland	56	51	47	40

Table 7. — Yields of Soybeans Planted on Four Dates, Carbondale

Variety	Date of planting			
	May 3	May 17	June 7	July 1
	Bushels per acre			
Corsoy	27	38	43	28
Cutler	62	46	54	27
Dare	72	45	37	32

Table 8. — Days to Maturity for Three Planting Dates, Columbia, Missouri (Six-Year Average)

Variety	Date of planting		
	May 1	June 1	June 12
	Days to maturity		
Hawkeye	122	104	98
Clark	149	115	105

Table 9. — Days to Maturity for Four Planting Dates, Carbondale

Variety	Date of planting			
	May 3	May 17	June 7	July 1
	Days to maturity			
Corsoy	118	103	107	101
Wayne	131	117	117	105
Cutler	145	133	117	108
Dare	159	153	138	122

Effect on maturity. The vegetative stage (planting to the beginning of flowering) is 45 to 60 days for full-season varieties planted at the normal time. This period is shortened as planting is delayed and may be only 25 to 26 days when these varieties are planted in late June or early July.

Soybeans are photoperiod responsive and the length of the night or dark period is the main factor in determining when flowering begins. The vegetative period also is influenced by temperatures — high temperatures shorten and low temperatures lengthen it — but the main effect remains that of the length of the dark period.

The length of the flowering period and that of pod filling also are shortened as planting is delayed. However, the effect of planting time on these periods is minor compared to that on the vegetative period.

As the length of the vegetative period grows shorter, the number of days it takes soybean plants to mature becomes fewer (Tables 8 and 9).

Planting Rate

A planting rate that results in 10 to 12 plants per foot of row at harvest in 40-inch rows, 6 to 8 plants in 30-inch rows, 4 to 6 plants in 20-inch rows, or 3 to 4 plants in 10-inch rows will provide maximum yield for May and very early June planting. Higher populations usually result in excessive lodging. Smaller populations often yield less, and the plants branch more and pod lower. This contributes to greater harvesting loss.

Populations should be increased by 50 to 100 percent for late June or early July plantings.

Planting Depth

Emergence will be more rapid and stands will be more uniform if soybeans are planted only 1½ to 2 inches deep. Deeper planting often results in disappointing stands.

Varieties differ in their ability to emerge when planted more than 2 inches deep, as the following table shows. Therefore, special attention should be given to planting depth of these varieties.

	Planting depth (in.)	*Percent emergence*
Beeson	2	71
	4	39
Hawkeye	2	80
	4	60

Row Width

If weeds are controlled, soybeans will yield more in narrow rows than in the traditional 38- to 40-inch rows (Table 10).

Since late-planted soybeans normally are not as tall as those planted in early May, the advantage of using narrow rows increases as planting is delayed past early June. Double-crop soybeans planted after the small-grain harvest should be planted in rows at least as narrow as 20 inches (Table 11).

Table 10. — Soybean Yields for Row Spacings of 10, 20, 30, and 40 Inches, Urbana

Variety	40 inches	30 inches	20 inches	10 inches
	Bushels per acre			
Wayne	47.0	51.2	52.4	53.6
Harosoy	38.8	42.0	45.0	48.0

Table 11. — Yield of Double-Crop Soybeans When Planted in 20- and 30-Inch Rows in 1972

	20-inch rows	30-inch rows
	Bushels per acre	
Dixon Springs	53	43
Brownstown	37	32
Urbana	33	24

Table 12. — Ability of Soybeans To Compensate for Loss of Stand, Urbana

Treatment, 20-foot rows	Percent of original stand	Yield (Bu./A.)
Six plants per foot of row	100	50
Three plants per foot of row	50	50
Three 40-inch gaps	50	41
Five 24-inch gaps	50	44
Four plants per foot of row	66	51
Two 40-inch gaps	66	43
Five 16-inch gaps	66	47
Five plants per foot of row	80	50
Two 24-inch gaps	80	47
Five 9.6-inch gaps	80	47

For many years some Illinois farmers have planted their soybeans with a small grain drill. Interest in this method is increasing, primarily because of the availability of herbicides that greatly reduce the probability of the need to cultivate. If weeds can be kept under control, the small grain drill is a practical narrow-row planting machine for soybeans. Research results do not always show an advantage for 7- or 8-inch rows over 15- or 20-inch rows, but the drilled beans usually yield 10 to 20 percent more than those planted in 40-inch rows. The key to the success of planting soybeans with a grain drill is good weed control. However, depth of planting is more difficult to control and you may wish to try the method on a relatively small acreage first.

See Illinois Cooperative Extension Service Circular 1161, *Narrow-Row Soybeans: What to Consider.*

When To Replant

An experiment at Urbana in 1969 demonstrated the ability of soybeans to compensate for loss of stand. The soybeans were planted in 30-inch rows at a rate of six plants per foot of row. They were thinned when in the second-leaf stage to stands of 50, 66, and 80 percent of the original stand. Plots were 20 feet long and the reductions in stand were accomplished by a uniform removal of plants and by removing all plants for specified distances in the row. For instance, three 40-inch gaps in a 20-foot row equal 50 percent of the original stand. The results of this experiment are shown in Table 12 and may be valuable when the question of whether to replant must be answered.

Double Cropping

See Illinois Cooperative Extension Service Circular 1106, *Double Cropping in Illinois.*

Seed Source

In order to ensure a good crop, you must do a good job of selecting seed. When evaluating seed quality, consider the percent germination, percent pure seed, percent inert matter, percent weed seed, and the presence of diseased and damaged kernels.

Samples of soybean seed taken from the planter box as farmers were planting showed that homegrown seed was inferior to seed from other sources (Tables 13 and 14). The number of seeds that germinate and the pure seed content of homegrown seeds were lower. Weed seed content, percent inert material (hulls, straw, dirt, and stones), and presence of other crop seeds (particularly corn) in homegrown seed were higher.

Farmers who purchased certified seed obtained a higher quality seed on the average than farmers purchasing uncertified seed.

This evidence indicates the Illinois farmer could improve the potential of his soybean production by using higher quality seed. Homegrown seed is the basic problem. Few farmers are equipped to carefully harvest, dry, store, and clean seeds, and to perform laboratory tests adequately to assure themselves of high-quality seed. Agriculture today is a professional enterprise. If a farmer is not a professional seed producer and processor, he may be well advised to market his soybeans and obtain high-quality seed from a reputable professional seedsman.

The state seed tag is attached to each legal sale from a seed dealer. Read the analysis and consider if the seed being purchased has the desired germination, purity of seed, and freedom from weeds, inert material, and other crop seeds. The certified tag verifies that an unbiased

Table 13. — Uncertified Soybean Seed Analysis by Seed Source

	Germination	Pure seed	Weed seed	Inert matter	Other crops
			Percent		
Homegrown	79.6	95.5	.02	2.29	2.27
Neighbor grown	80.8	97.5	.01	2.06	.41
Seed dealer	81.2	97.8	.001	1.48	.77

Table 14. — Certified and Uncertified Soybean Seed Analysis

	Samples	Germination	Pure seed	Weed seed	Inert matter	Other crops
				Percent		
Uncertified	363	80.2	95.5	.02	2.6	2.0
Certified	56	84.2	98.7	.001	1.2	.2

nonprofit organization (the Illinois Crop Improvement Association) has conducted inspections in the production field and in the processing plant. These inspections make certain the seeds are of a particular variety as named and have met certain minimum seed-quality standards. Some seedsmen may have higher quality seed than others. It pays to read the tag.

Varieties

Soybean varieties are divided into maturity groups according to their relative time of maturity (Table 15). Varieties of Maturity Group I are nearly full season in northern Illinois but are too early for good growth and yield farther south. In extreme southern Illinois the Maturity Group IV varieties range from early to midseason in maturity.

Maturity Group I

Harlon was developed at the Harrow Research Station in Ontario, Canada, and released in 1976. It matures 4 days earlier than Hodgson and is about 1 inch taller than Hark. It is equal to Hark in lodging resistance and is resistant to Phytophthora rot.

Hodgson was released by the University of Minnesota and the USDA in 1974. It matures 4 days earlier than Hark and is about 2 inches shorter. Hodgson is similar to Hark in lodging resistance and is susceptible to Phytophthora rot.

Hodgson 78 was developed and released by the University of Minnesota Agricultural Experiment Station. It is similar to Hodgson in all respects except that it is resistant to races 1 and 2 of Phytophthora root rot.

Maturity Group II

Amsoy is a high-yielding variety, second only to Corsoy among the Group II varieties, and is very popular. It is very susceptible to Phytophthora root rot and purple stain of the seed coat. Purple stain is occasionally a problem, usually occurring in southern Illinois. The lodging resistance of Amsoy is superior to that of most other Group II varieties.

Amsoy 71 was developed at Purdue University. It is similar to Amsoy except that it is resistant to Phytophthora root rot.

Beeson is resistant to Phytophthora root rot. It was released by Purdue University in August, 1968. The variety has yielded nearly as well as Amsoy when root rot was not present. In the presence of root rot, Beeson has yielded much more than Amsoy or Corsoy. Beeson matures about 3 days later than Amsoy and 6 days later than Corsoy. Lodging resistance of Beeson is slightly greater than that of Amsoy or Corsoy. It is similar in height to Corsoy and 1 to 3 inches shorter than Amsoy. It has a spreading leaf canopy.

Beeson 80 is an improved version of the original Beeson variety and is similar to Beeson in maturity and appearance. However, it is resistant to 7 different races of Phytophthora root rot, whereas the original Beeson variety is resistant to only 2 races. Illinois growers can obtain seed for the 1981 crop year.

Century was developed at Purdue University and will be available to growers for the first time in 1981. It matures roughly 3 days later that Corsoy. Century is resistant to races 1 and 2 of Phytophthora root rot and has better lodging resistance than Beeson.

Corsoy was released in 1967. It is similar to Amsoy in growth habit, but averages 2 inches shorter. It is susceptible to Phytophthora root rot, so grow it where this disease is not a problem. Corsoy has yielded 1 to 2 bushels per acre more than Amsoy and matures 1 to 3 days earlier. Corsoy is slightly less resistant to lodging than Amsoy. Corsoy and Amsoy should replace the older Group II varieties unless Phytophthora is present.

Corsoy 79 is an improved version of Corsoy developed by the University of Illinois Agricultural Experiment Station. It is similar to Corsoy in maturity and appearance, but is resistant to 7 races of Phytophthora root rot, whereas Corsoy has no resistance. Corsoy 79 will be available beginning in 1981.

Gnome was developed by the Ohio Agriculture Experiment Station and will be available to growers beginning in 1981. Its determinate growth habit makes the plant quite short and very resistant to lodging. It matures at about the same time as Beeson. Gnome performs best when grown in narrow rows and when given an abundance of fertilizer and water.

Harcor, developed at the Harrow Research Station in Ontario, Canada, was released in 1976. It is comparable to Corsoy in height and lodging resistance and matures 1 to 2 days later. It is resistant to Phytophthora rot.

Nebsoy was developed in Nebraska and will be available to growers beginning in 1981. It matures at the same time as Amsoy. The plants are roughly 6 inches shorter than those of Amsoy and have much greater lodging resistance. Nebsoy is resistant to races 1 and 2 of Phytophthora root rot.

Wells was developed at Purdue University and released in 1973. It is similar to Corsoy in plant height and seed size but matures 1 to 2 days earlier. Wells is superior to Amsoy 71, Beeson, and Corsoy in lodging resistance. It is resistant to Phytophthora root rot and frogeye leaf spot race 2.

Wells II has a maturity identical to that of Wells. The main advantage of Wells II is its resistance to five additional races of Phytophthora. Like Wells, it has very good yield and excellent lodging resistance. Seed will be available for planting in 1980.

Maturity Group III

Calland has Phytophthora root rot resistance and was released by Purdue University in August, 1968. It has

Table 15. — Characteristics and Parentage of Soybean Varieties

Maturity group and variety	Parentage and year released[a]	Flower color	Pubescence color	Pod color	Seed luster	Hilum color[b]
I						
Harlon	Blackhawk X Harosoy 63 (1976)	white	gray	brown	dull	yellow
Hodgson[c]	Corsoy X M372 (1974)	purple	gray	brown	dull	buff
Hodgson 78[c]	Hodgson[7] X Merit (1978)	purple	gray	brown	dull	buff
II						
Amsoy	Adams X Harosoy (1965)	purple	gray	tan	shiny	yellow
Amsoy 71[c]	Amsoy[8] X C1253 (Blackhawk X Harosoy) (1971)	purple	gray	tan	shiny	yellow
Beeson	(Blackhawk X Harosoy) X Kent (1968)	purple	gray	brown	shiny	imp. black
Beeson 80[c]	Beeson[8] X Arksoy (1979)	purple	gray	brown	dull	imp. black
Century[c]	Calland X Bonus (1979)	purple	tawny	brown	dull	imp. black
Corsoy	Harosoy X Capital (1967)	purple	gray	brown	dull	yellow
Corsoy 79	Corsoy[6] X Lee 68 (1979)	purple	gray	brown	dull	yellow
Gnome[c]	Williams X Ransom (1979)	purple	tawny	tan	shiny	black
Harcor	Corsoy X 0X383 (1976)	purple	gray	brown	shiny	yellow
Nebsoy[c]	C1432 X C1430 (1979)	white	gray	brown	shiny	buff
Wells[c]	(Harosoy X C1079) X C1253 (1973)	purple	gray	brown	dull	imp. black
Wells II[c]	Wells X Mack (1979)	purple	gray	brown	dull	imp. black
III						
Calland	(Blackhawk X Harosoy) X Kent (1968)	purple	tawny	brown	dull	black
Cumberland	Corsoy X Williams (1978)	purple	gray	brown	shiny	imp. black
Elf	Williams X Ransom dt_1 (1978)	purple	tawny	tan	shiny	black
Oakland	L66L-137 X Calland (1978)	purple	tawny	brown	dull	black
Pella[c]	L66L-137 X Calland (1979)	purple	tawny	tan	dull	black
Wayne	(Lincoln, Richland, CNS) X Clark (1964)	white	tawny	brown	shiny	black
Will	Williams[6] X (Clark[6] X T117) (1979)	white	tawny	tan	shiny	black
Williams	Wayne X L57-0034 (1972)	white	tawny	tan	shiny	black
Williams 79	Williams[6] X Lee 68 (1979)	white	tawny	tan	dull	black
Woodworth	Wayne X L57-0034 (1975)	white	tawny	tan	dull	black
IV						
Bonus[c]	C1266R X C1253 (1972)	purple	gray	brown	dull	imp. black
Crawford[c]	Williams X Columbus (1978)	purple	tawny	brown	shiny	black
Cutler 71[c]	Cutler[4] X Kent — Rpo rxp — SL5 (1971)	purple	tawny	brown	shiny	black
DeSoto[c]	L66L-140 X Columbus (1979)	purple	tawny	brown	dull	black
Franklin	L12 X Custer (1978)	purple	gray	brown	dull	imp. black
Union	Williams X SL11 (Wayne RpmRps) (1977)	white	tawny	tan	shiny	black
V						
Bedford	Forrest (2) X (D68-18 X PI88788) (1978)	white	tawny	tan	shiny	black
Essex	Lee X 55-7075 (1973)	purple	gray	brown	....	buff
Forrest[c]	Dyer X Bragg (1973)	white	tawny	....	shiny	black

[a] Superscript indicates the number of crosses in a backcrossing program. [b] imp. = imperfect. [c] U.S. Protected Variety — see page 13.

yielded nearly as well as Wayne in the absence of Phytophthora root rot. Where Phytophthora root rot is severe, Calland has yielded much more than Wayne. Calland matures 1 to 2 days later than Wayne, averages about 1 inch taller, and has a little greater resistance to lodging.

Cumberland was released by Iowa with Illinois participating. This new variety was selected from the cross of Corsoy and Williams. Maturity of Cumberland is about 2 days before Williams, but yields have been better than those of Williams. Plant size is similar to both Woodworth and Williams with lodging to a degree similar to Williams. It is susceptible to Phytophthora.

Elf is a considerably shorter soybean than most others available. It matures the same time as Williams but may be only half as tall, greatly reducing its lodging tendency. The small canopy of Elf makes it adapted to narrow rows. Production in rows wider than 30 inches will result in relatively poor performance because of its inability to fill in row middles with its smaller canopy. The determinate growth habit of Elf also contrasts with the indeterminate growth habit of virtually all other Group III varieties. Combined with environmental stress early in the growing season, the determinate growth of Elf will result in an even more compact short plant. Such a plant tends to be less productive and more difficult to harvest. Therefore, an environment conducive to high yields in which Elf can be seeded in narrow rows will be where maximum yields would be expected from this variety.

Oakland is a 1978 Iowa release in which Illinois is participating. It has resistance to Phytophthora root rot. It is similar in size to Williams but matures about 2½ days earlier. Lodging of Oakland is less than Williams but Oakland generally will yield no better.

Pella was developed by the Iowa Agricultural Experiment Station and will be available to growers beginning in 1981. It lodges less than Williams and is resistant to races 1 and 2 of Phytophthora root rot. Pella matures 3 days earlier than Cumberland.

Table 16. — Average Soybean Yields at Selected Locations in Illinois, 1979–80

Variety	DeKalb	Pontiac	Urbana	Brownstown	Girard	Belleville	Eldorado
			Bushels per acre				
I							
Hodgson 78[a]	40	..	..	..	..	..	..
II							
Beeson 80[a]	44	36	50	..	39	..	..
Century[a]	47	41	48	..	40	..	..
Corsoy 79	48	40	46	..	40	..	..
Gnome[a]	48	44	46	..	42	..	..
Nebsoy[a]	45	38	48	..	39	..	..
Wells II[a]	43	38	48	..	38	..	..
III							
Cumberland	..	43	52	45	50	52	54
Elf	..	42	52	40	45	50	48
Pella[a]	..	38	53	43	45	47	50
Will	..	41	54	40	45	47	51
Williams 79	..	40	53	44	51	49	50
IV							
Crawford[a]	..	..		38		43	43
DeSoto[a]	..	..	..	42	..	48	51
Franklin	..	..	..	36	..	39	44
Union	..	..	..	41	45	49	52
V							
Essex	..	..	..	..	..	43	50

[a] U.S. Protected Variety — see page 13.

Wayne is a high-yielding variety in central and south central Illinois. It has some tendency to shatter and develops iron-deficiency chlorosis (yellowing of leaves) on high-lime soils (pH 7 or higher). It is susceptible to pod and stem blight, so at times it will have poor seed quality. Its advantages are resistance to bacterial pustule and high yields. Wayne is classed as susceptible to Phytophthora root rot but appears to have some tolerance to this disease.

Will was developed by the University of Illinois Agricultural Experiment Station. Its unique semideterminate growth habit produces a plant that is roughly 6 inches shorter than Williams and that has a high degree of lodging resistance. Will matures roughly 5 days before Williams. It is available for the 1981 crop year.

Williams was developed by the USDA in cooperation with the University of Illinois and was released in 1972. It is superior to other varieties adapted to central and southern Illinois in seed quality (freedom from wrinkling, growth cracks, greenishness, and moldy or rotten seeds). It matures about 3 days later than Wayne but is similar in plant height and seed size. Williams is superior to both Wayne and Calland in lodging and shatter resistance. It is resistant to bacterial pustule and powdery mildew. Williams is classed as susceptible to Phytophthora root rot but appears to have some tolerance to this disease.

Williams 79 is an improved version of Williams developed at the University of Illinois Agricultural Experiment Station. It is similar to Williams in maturity and appearance but is resistant to 7 races of Phytophthora root rot, whereas Williams has no resistance. This improved variety will be available to growers beginning with the 1981 crop year.

Woodworth is a selection from the same cross as Williams. It was released by the USDA and the University of Illinois in 1975. It is similar to Williams in height, lodging resistance, and seed quality but matures 3 to 4 days earlier. It is classed as susceptible to Phytophthora rot but appears to have some tolerance to the disease. Woodworth is resistant to bacterial pustule and superior to Wayne and Calland in shattering resistance.

Table 17. — Reactions of Soybean Varieties to Phytophthora Root Rot Disease

Maturity group	Susceptible to Phytophthora root rot	Resistant to races 1 and 2	Resistant to races 1, 2, and others
I	Harlon Hodgson	Hodgson 78	
II	Amsoy Corsoy Gnome	Amsoy 71 Beeson Century Harcor Nebsoy Wells	Beeson 80 Corsoy 79 Wells II
III	Cumberland Elf Wayne Will Williams Woodworth	Oakland Pella	Williams 79
IV	Crawford Desoto	Bonus Cutler 71 Franklin Union	
V	Bedford Essex Forrest		

Maturity Group IV

Bonus was developed by the USDA in cooperation with Purdue University. It matures about 2 days earlier than Cutler 71 and grows about 3 to 4 inches taller. The seed of Bonus is smaller than that of Cutler 71, and the quality (freedom from wrinkling, growth cracks, greenness, and moldy or rotten seeds) is better. Bonus is resistant to Phytophthora root rot but susceptible to frogeye leaf spot, bacterial pustule, and downy mildew. It tends to shatter more than Cutler 71. Bonus is similar to other varieties in oil content but is 1 to 2 percent higher in protein content.

Crawford was developed from the cross Williams X Columbus and released in 1978. Maturity is later than Cutler 71 and Kent, but earlier than Columbus. The chief advantage of Crawford is that it yields more than other varieties of similar maturity. Lodging and plant height of Crawford are greater than Cutler 71 or Kent.

Cutler and **Cutler 71** were developed by Purdue University. Cutler 71 is resistant to races 1 and 2 of Phytophthora root rot. Both varieties mature about 3 days later than Bonus.

DeSoto was developed at Kansas State University. It matures about 3 days later than Union and has considerably better lodging resistance. Growers can obtain seed for the first time in 1981.

Franklin is an Illinois and Missouri developed variety released in 1978. Resistance to race 3 of soybean cyst nematode and good yields are outstanding features of this new variety. Maturity of Franklin is very similar to Custer, a variety which Franklin will likely replace. Lodging and seed shattering of Franklin is less than that of Custer too. Yields of Franklin have consistently been better than those of Custer, which also has resistance to race 3 of the cyst nematode.

Union has resistance to Phytophthora and downy mildew. It is also resistant to bacterial pustule. Union matures about 2 days earlier than Cutler 71. Union is comparable to Cutler 71 in plant height and lodging resistance. Seed quality is better than for Cutler 71 but not quite equal to that of Williams.

Maturity Group V

Bedford was jointly developed by Mississippi and Tennessee and released in 1978. The major advantage of Bedford is its resistance to races 3 and 4 of the soybean cyst nematode. Where race 4 of the cyst nematode is a problem Bedford will be useful by replacing Forrest which is susceptible to the pest. When race 4 is not a problem, Bedford and Forrest have similar yields. Heavy seeding rates for Bedford cannot be used because of severe lodging tendencies of the variety.

Table 18. — Soybean Variety Descriptions

Maturity group and variety	Relative maturity date[a]	Lodging[a]	Plant height[a]	Seed quality[a]	Seeds per pound[a]	Seed content[a] Protein	Seed content[a] Oil
		score[b]	*inches*	*score*[c]	*number*	*percent*	*percent*
I							
Hodgson 78[e]	0[d]	1.4	36	1.6	2,600	39.9	21.2
II							
Wells II[e]	5	1.7	38	2.5	2,650	42.1	20.4
Corsoy 79	5	2.4	39	2.0	2,800	40.5	20.9
Harcor	6	2.6	39	1.9	2,850	40.8	20.5
Nebsoy[e]	8	1.6	35	2.3	2,550	40.9	20.1
Amsoy 71[e]	8	2.3	42	2.5	2,500	...	...
Century[e]	9	1.9	38	2.1	2,350	42.6	19.7
Beeson 80[e]	10	2.2	38	2.2	2,300	42.0	20.1
Gnome[e]	11	1.8	26	1.6	2,750	42.4	20.1
III							
Pella[e]	17	1.9	38	2.2	2,300	40.3	21.1
Woodworth	17	..	..	..	....	...	...
Will	17	1.7	32	1.8	2,800	42.3	20.7
Calland	19	..	..	..	....	...	...
Cumberland	19	2.2	36	2.1	2,500	41.4	21.5
Williams 79	20	2.1	40	1.8	2,650	42.2	20.6
Elf	22	1.5	22	1.8	2,800	42.9	20.0
IV							
Bonus[e]	25	..	..	..	....	...	...
Union	26	2.2	39	2.2	2,500	41.7	20.0
Cutler 71[e]	28	..	..	..	....	...	...
DeSoto[e]	29	1.9	36	2.1	2,800	40.8	20.4
Franklin	32	2.2	40	2.2	3,000	37.9	21.1
Crawford[e]	38	2.2	40	1.9	2,950	41.3	19.8

[a] USDA Regional Uniform Test data.
[b] Lodging score: 1 = erect, 5 = prostrate.
[c] Seed quality score: 1 = excellent, 5 = very poor (wrinkled, shriveled, green, moldy, imperfect seed coat, or other defects).
[d] Days to maturity following Hodgson 78.
[e] U.S. Protected Variety — see page 13.

Essex was developed at the Virginia Agricultural Experiment Station. It matures about 2 days earlier than Dare, grows about 4 to 6 inches shorter, and is more resistant to lodging. It is resistant to bacterial pustule, several races of downy mildew, and frogeye leaf spot and moderately resistant to Phytophthora rot. It is susceptible to the soybean cyst nematode.

Forrest was developed at the Delta Branch Agricultural Experiment Station, Mississippi. It is similar to Dare in maturity. It is resistant to races 1 and 3 of the soybean cyst nematode, bacterial pustule, wild fire, and target spot and moderately resistant to Phytophthora rot. It has excellent resistance to shattering.

Private Varieties and Blends

Each year the University of Illinois conducts the Commercial Soybean Performance Test on many of the 300 different soybean varieties, blends, and brands now sold in Illinois. The results are published in an Extension Service circular and are available from all county Extension offices around January 1. The test report summarizes the yield, maturity, lodging resistance, height, and shattering resistance of the soybeans tested.

Blends of two or more varieties are usually identified by a brand name, such as "John Doe 200 Brand." Most blends are reconstituted with the same varieties in the same proportions each year; however, neither the Illinois Seed Law nor the Federal Seed Law requires this consistency.

A survey of private soybeans available for Illinois planting in 1981 indicates that 195 soybeans are varieties and 105 are blends or brands.

PLANT VARIETY PROTECTION ACT

Congress passed the Plant Variety Protection Act in 1970. This law provides the inventor or owner of a new variety of certain seed-propagated crops the right to exclude others from selling, offering for sale, reproducing, exporting, or using the variety to produce a hybrid, different variety, or blend.

These rights are not automatic. The owner must apply for a certificate of protection. If the owner does not choose to protect the variety, it is public property and anyone may legally reproduce it and sell seed of it.

Essentially all varieties of the self-pollinated crops commonly grown in Illinois — such as soybeans and wheat — developed by private industry since 1970 are protected varieties. Many of the varieties developed at state experiment stations also are protected.

The law allows you, if you desire, to save your own production of a protected variety for seed. However, it does place certain restrictions on the sale of seed of a protected variety.

Under one provision of the act, the owner may stipulate that the variety be sold by variety name only as a class of certified seed. Seed of varieties protected under this provision of the act cannot be sold by variety name unless it is produced according to the standards and procedures of one of the official seed certification agencies in the United States. In Illinois, this is the Illinois Crop Improvement Association. The sale of uncertified seed of varieties protected in this manner also is a violation of the Federal Seed Act.

If the owner of a protected variety does not subscribe to the certified seed provision of the act, a farmer whose primary occupation is producing food or feed may sell seed of the protected variety to another farmer whose primary occupation is producing crops for food or feed. However, the second farmer may not sell as seed any of the crop that he produces.

Even if the protected variety is not covered by the certified seed provision of the act, anything advertising the sale of seed of that variety — including farm sale bills — usually is considered an infringement of the owner's rights. Therefore, any person desiring to sell seed of a protected variety must first obtain permission from the owner of the variety.

The container in which seed of a protected variety is sold should carry a label identifying the seed as that of a protected variety.

WHEAT

Both soft red and hard red winter wheat are grown in Illinois. Soft wheat is planted throughout Illinois, and most soft wheat varieties are sufficiently winter hardy to be grown anywhere in the state. Essentially all the hard wheat is grown in the northern half of Illinois, for two reasons. First, most of the popular hard varieties are more winter hardy than the soft varieties, and second, markets buying wheat in central and northern Illinois have traditionally preferred hard wheat. Some still discount soft wheat, and some refuse to buy it; however, their number is declining.

Wheat growers whose market does not discriminate against soft wheat but who are not presently growing it may be attracted by the yield, earlier maturity, and lodging resistance of some of the newer soft varieties. Producers in the northernmost counties who decide to grow soft wheat may also want to choose Argee for its excellent winter hardiness.

Date of Seeding

The Hessian-fly-safe dates for each county in Illinois are given in Table 19. Wheat planted on or after the fly-safe date is much less likely to be damaged by the insect than wheat planted earlier. It will also be less severely damaged in the fall by various diseases, for example, by Septoria leaf spot, which is favored by the rank fall growth usually associated with early planting. Since the aphids that carry the barley yellow dwarf (BYD) virus are killed by freezing temperatures, the effects of BYD will be less severe if wheat is planted shortly before the first killing freeze. Finally, wheat planted on or after the fly-safe date will probably suffer less from soil-borne mosaic; most of the soft red wheat varieties carry good resistance to this disease but may show symptoms if severely infested.

Rate of Seeding

Rate-of-seeding trials involving several different wheat varieties have been conducted in Illinois. The results of these trials indicate that 1½ bushels (90 pounds) of good seed per acre is adequate when planting at the normal time. The rate may be increased if seeding is delayed well past the fly-free date.

Seed Treatment

Treating wheat seeds with the proper fungicide or mixture of fungicides is a cheap way to help insure improved stands and better grain quality. In addition, the yield from treated seed usually will be higher than that from untreated seed.

The Department of Plant Pathology suggests several fungicides for treating seeds, including captan, maneb, HBC, thiram, and Vitavax. Vitavax controls loose smut in wheat and barley and should be used if this disease was present in the field where the seed was produced. Since Vitavax is not effective on some of the other seed-borne diseases that cause seedling blight (such as Septoria), another fungicide should be used along with Vitavax. Should you desire additional information concerning wheat diseases or seed treatment methods and materials, contact the University of Illinois Department of Plant Pathology or your county extension adviser.

Depth of Seeding

Wheat should not be planted more than 1 to 2 inches deep. Deeper planting may result in poor emergence. This is particularly true of the semidwarf varieties because coleoptile length is positively correlated with plant height.

Table 19. — Average Date of Seeding Wheat for Highest Yield

County	Average date of seeding wheat for highest yield	County	Average date of seeding wheat for highest yield
Adams	Sept. 30-Oct. 3	Lee	Sept. 19-21
Alexander	Oct. 12	Livingston	Sept. 23-25
Bond	Oct. 7-9	Logan	Sept. 29-Oct. 3
Boone	Sept. 17-19	Macon	Oct. 1-3
Brown	Sept. 30-Oct. 2	Macoupin	Oct. 4-7
Bureau	Sept. 21-24	Madison	Oct. 7-9
Calhoun	Oct. 4-8	Marion	Oct. 8-10
Carroll	Sept. 19-21	Marshall-Putnam	Sept. 23-26
Cass	Sept. 30-Oct. 2		
Champaign	Sept. 29-Oct. 2	Mason	Sept. 29-Oct. 1
Christian	Oct. 2-4	Massac	Oct. 11-12
Clark	Oct. 4-6	McDonough	Sept. 29-Oct. 1
Clay	Oct. 7-10	McHenry	Sept. 17-20
Clinton	Oct. 8-10	McLean	Sept. 27-Oct. 1
Coles	Oct. 3-5	Menard	Sept. 30-Oct. 2
Cook	Sept. 19-22	Mercer	Sept. 22-25
Crawford	Oct. 6-8	Monroe	Oct. 9-11
Cumberland	Oct. 4-5	Montgomery	Oct. 4-7
DeKalb	Sept. 19-21	Morgan	Oct. 2-4
DeWitt	Sept. 29-Oct. 1	Moultrie	Oct. 2-4
Douglas	Oct. 2-3	Ogle	Sept. 19-21
DuPage	Sept. 19-21	Peoria	Sept. 23-28
Edgar	Oct. 2-4	Perry	Oct. 10-11
Edwards	Oct. 9-10	Piatt	Sept. 29-Oct. 2
Effingham	Oct. 5-8	Pike	Oct. 2-4
Fayette	Oct. 4-8	Pope	Oct. 11-12
Ford	Sept. 23-29	Pulaski	Oct. 11-12
Franklin	Oct. 10-12	Randolph	Oct. 9-11
Fulton	Sept. 27-30	Richland	Oct. 8-10
Gallatin	Oct. 11-12	Rock Island	Sept. 20-22
Greene	Oct. 4-7	St. Clair	Oct. 9-11
Grundy	Sept. 22-24	Saline	Oct. 11-12
Hamilton	Oct. 10-11	Sangamon	Oct. 1-5
Hancock	Sept. 27-30	Schuyler	Sept. 29-Oct. 1
Hardin	Oct. 11-12	Scott	Oct. 2-4
Henderson	Sept. 23-28	Shelby	Oct. 3-5
Henry	Sept. 21-23	Stark	Sept. 23-25
Iroquois	Sept. 24-29	Stephenson	Sept. 17-20
Jackson	Oct. 11-12	Tazewell	Sept. 27-Oct. 1
Jasper	Oct. 6-8	Union	Oct. 11-12
Jefferson	Oct. 9-11	Vermilion	Sept. 28-Oct. 2
Jersey	Oct. 6-8	Wabash	Oct. 9-11
Jo Daviess	Sept. 17-20	Warren	Sept. 23-27
Johnson	Oct. 10-12	Washington	Oct. 9-11
Kane	Sept. 19-21	Wayne	Oct. 9-11
Kankakee	Sept. 22-25	White	Oct. 9-11
Kendall	Sept. 20-22	Whiteside	Sept. 20-22
Knox	Sept. 23-27	Will	Sept. 21-24
Lake	Sept. 17-20	Williamson	Oct. 11-12
LaSalle	Sept. 19-24	Winnebago	Sept. 17-20
Lawrence	Oct. 8-10	Woodford	Sept. 26-28

Width of Row

Research on row width shows no advantage for planting wheat in rows narrower than 7 or 8 inches, which is considered normal. Yield is not improved by planting in narrower rows. It is usually reduced by wider rows, as the following table shows.

Row spacing (in.)	*Two-year average yield (bu./A.)*
8	37.8
16	31.6
24	27.2

Varieties

Soft Red Winter Wheat

Abe (a protected variety)* is a beardless white-chaff variety released by Purdue University and the USDA in 1972. It is similar to Arthur in parentage, lodging resistance, maturity, and weight per bushel. Under some conditions it will be slightly shorter. Abe is resistant to the Hessian fly, leaf rust, and the soil-borne mosaic virus. It is moderately susceptible to powdery mildew.

Arthur is a beardless white-chaff variety released in 1967 by the Purdue Agricultural Experiment Station and the USDA. It is relatively short and stiff strawed. It is moderately resistant to loose smut, stem rust, leaf rust, and the soil-borne mosaic virus. It is susceptible to one race of the Hessian fly common to Illinois.

Arthur 71 (a protected variety)* was released in 1971 by Purdue University. It is similar to Arthur except that it is resistant to races A and B of the Hessian fly and is more resistant to leaf rust.

Argee (a protected variety)* is a bearded white-chaff variety released in 1976 by the University of Wisconsin. Argee is 2 to 4 inches taller than Abe, is less resistant to lodging, and matures 6 to 8 days later. It is very winter hardy and is resistant to leaf rust, stem rust, and loose smut.

Beau (a protected variety)* is a beardless white-chaff variety developed at Purdue University and released in 1976. It is similar to Abe in maturity and height and is slightly more resistant to lodging. Beau is resistant to the Hessian fly and the soil-borne mosaic virus and has some resistance to Septoria leaf spot and powdery mildew.

Double Crop is a beardless white-chaff variety selected out of Arthur at the University of Arkansas. It matures 2 to 4 days earlier than Arthur and is slightly shorter in height. Double Crop has good lodging resistance but tends to shatter.

Hart is a bearded white-chaff variety released jointly by the University of Missouri and Pennsylvania State University. It matures 1 to 2 days later than Abe, grows to about the same height, and is slightly less resistant to lodging. It is not as winter hardy as Arthur, Abe, or Beau. It has some tolerance to Septoria leaf spot, loose smut, and the barley yellow dwarf virus. It is susceptible to the Hessian fly.

Oasis (a protected variety)* is a beardless white-chaff variety developed at Purdue University and released in 1973. It matures 1 to 2 days later than Arthur, grows 1 to 2 inches taller, and is less resistant to lodging. Oasis has good resistance to leaf rust, loose smut, the Hessian fly, the soil-borne mosaic virus, and Septoria leaf spot. It is moderately resistant to powdery mildew.

Pike (a protected variety)* was released by the University of Missouri in 1980. It matures at about the same time as Hart. Although it grows 1 to 2 inches shorter than Hart, it is slightly more susceptible to lodging. Pike is moderately resistant to the Hessian fly and Septoria leaf spot but is susceptible to powdery mildew.

Roland is a beardless white-chaff variety developed at the University of Illinois and released in 1977. It matures about 2 days later than Abe, grows 2 to 4 inches shorter, and is more resistant to lodging. Roland weighs 1 or 2 pounds less per bushel than Abe. It is moderately resistant to leaf rust, powdery mildew, Septoria leaf spot, and the barley yellow dwarf virus. It is susceptible to the Hessian fly.

Rosen is a beardless white-chaff variety developed at the University of Arkansas. It matures about 2 days later than Abe, grows 2 to 4 inches shorter, and is more resistant to lodging. Rosen tends to weigh 1 to 2 pounds less per bushel than Abe or Arthur. It is moderately resistant to leaf rust, powdery mildew, and Septoria leaf spot but is susceptible to the Hessian fly. Rosen is probably not as winter hardy as most soft wheat varieties.

Stoddard is a beardless white-chaff variety developed at the University of Missouri and released in 1973. It matures about 2 days later than Arthur and grows 3 to 4 inches taller. It is comparable to Arthur in lodging resistance. It has good resistance to leaf rust but is moderately susceptible to the soil-borne mosaic virus and is susceptible to stem rust, the Hessian fly, and Septoria leaf spot.

Sullivan (a protected variety)* is a beardless white-chaff variety developed at Purdue University and released in 1977. It matures 1 to 2 days earlier than Abe, is slightly taller, and is slightly less resistant to lodging. It is resistant to the Hessian fly, powdery mildew, Septoria leaf spot, loose smut, the common races of leaf rust, and some races of stem rust. It is the first variety of soft red winter wheat to have moderate resistance to the take-all root rot disease that has been a problem in some wheat fields in recent years.

Titan (a protected variety)* is a beardless white-chaff variety developed at Ohio State University and released in 1978. It matures about 6 days later than Arthur, grows 2 to 3 inches taller, and has comparable lodging resistance. Titan is resistant to leaf rust, powdery mildew, and loose smut. It is moderately resistant to Septoria leaf spot and the barley yellow dwarf virus but is susceptible to the Hessian fly. It is slightly less winter hardy than Arthur.

*** See Plant Variety Protection Act, page 13.**

Table 20. — Yield Record of Wheat Varieties in University of Illinois Tests

Variety	Brownstown Research Center 1980 Yield		Brownstown 1979–80 Yield		Urbana Research Center 1980 Yield		Urbana 1978–80 Yield		Northern Illinois Research Center 1980 Yield		Northern Illinois 1979–80 Yield		Average date headed at Urbana
	Yield	Test weight	Yield	Test weight	Yield	Test weight	Yield	Test weight	Yield	Test weight	Yield	Test weight	
	bu./A.	lb./bu.	bu./A.	lb./bu.	bu./A.	lb./bu.	bu./A.	lb./bu.	bu./A.	lb./bu.	bu./A.	lb./bu.	May
SOFT WHEAT													
Abe[a]	68	59	62	60	89	61	83	61	69	56	67	58	24
Arthur	68	59	65	60	87	61	84	61	60	57	61	59	24
Arthur 71[a]	63	60	61	60	89	61	80	60	63	58	63	59	24
Argee[a]	60	56	53	54	79	57	75	55	72	55	75	57	32
Beau[a]	58	60	57	60	83	61	82	61	64	56	63	58	25
Double Crop	51	59	56	61	74	60	75	60	..	..	..	..	20
Hart	74	57	67	59	92	60	88	60	71	56	71	58	25
Oasis[a]	58	59	59	60	84	61	76	60	63	57	62	59	25
Pike[a]	99	60	..	..	87	60	..	..	74	54	..	..	25
Roland	79	60	67	58	88	59	85	57	61	57	68	59	26
Rosen	82	58	..	..	89	59	..	..	72	55	..	..	26
Stoddard	60	60	61	60	78	61	75	60	62	54	63	57	26
Sullivan[a]	60	59	63	61	85	60	70	60	62	57	59	59	22
Titan[a]	75	59	68	55	87	58	81	58	70	55	74	57	30
HARD WHEAT													
Bennett[a]	..	..	..	..	71	59	75	59	..	..	..	..	26
Centurk[a]	..	..	..	..	72	60	72	60	63	57	64	59	27
Centurk 78[a]	..	..	..	..	75	60	74	60	67	57	68	59	27
Newton[a]	..	..	..	..	75	60	73	59	65	58	65	60	25
Parker	..	..	..	..	83	61	73	61	65	58	63	60	26

[a] U.S. Protected Variety — see page 13.

Hard Red Winter Wheat

Bennett (a protected variety)* is a bearded white-chaff variety developed at the University of Nebraska and released in 1978. It matures at about the same time as Centurk, grows 2 to 3 inches shorter, and has better lodging resistance. It has good resistance to leaf and stem rust and moderate resistance to the soil-borne mosaic virus, but it is susceptible to the Hessian fly.

Centurk (a protected variety)* is a bearded white-chaff variety developed at the University of Nebraska and released in 1970. The name is a contraction of "Centennial Turkey," which reflects the presence of Turkey wheat parentage and honors the centennial of the introduction of Turkey wheat into the United States in 1873-74. Centurk matures 1 to 2 days later than Parker and is not as resistant to lodging. It is resistant to stem rust and moderately resistant to leaf rust and the soil-borne mosaic virus, but it is susceptible to the Hessian fly.

Centurk 78 (a protected variety)* is a selection of Centurk released by the University of Nebraska in 1978. It is similar to Centurk in all agronomic characteristics except that it has a higher yield.

Gage is a bearded white-chaff variety released by Nebraska in 1963. It matures at about the same time as Centurk and has similar straw strength. It is moderately resistant to the soil-borne mosaic virus but is susceptible to the rusts and the Hessian fly.

Newton (a protected variety)* is a bearded white-chaff variety developed at Kansas State University. It matures about 2 days earlier than Centurk, grows about 4 inches shorter, and has better lodging resistance. Newton is moderately resistant to leaf and stem rust and the soil-borne mosaic virus but is susceptible to the Hessian fly. It is less winter hardy than Centurk and for that reason should probably not be planted in extreme northern Illinois.

Parker is a bearded white-chaff variety developed at Kansas State University and released in 1966. It matures 1 to 2 days earlier than Centurk and grows to about the same height, but it is more resistant to lodging. Parker is susceptible to stem rust and to the soil-borne mosaic virus and is moderately susceptible to leaf rust. It is resistant to the Hessian fly.

Hard Red Spring

Spring wheat is not well adapted to Illinois. Since it matures more than 2 weeks later than hard red winter wheat, it is in the process of filling kernels during the hot weather typical of late June and the first half of July. Consequently, yields average only about 50 to 60 percent those of winter wheat.

With the exception of planting time, production practices for spring wheat are similar to those for winter wheat. Spring wheat should be planted in the late winter or early spring, as soon as a seedbed can be prepared.

* See Plant Variety Protection Act, page 13.

Table 21. — Hard Red Spring Wheat Performance, DeKalb

Variety[a]	1980 Yield	1980 Test weight	1978–80 Yield	1978–80 Test weight
	bu./A.	*lb./bu.*	*bu./A.*	*lb./bu.*
Ellar	26	59	34	60
Eureka	29	58	34	56
Selkirk	26	57	36	58
Tioga	29	59	38	60
Olaf	27	60	34	58
Era	27	57	36	58
Fletcher	23	57	31	56
Triticale	19	41	28	42

[a] Listed with earliest at top and latest at bottom of table.

Era is an awned, midseason to late semidwarf with good lodging resistance. It is resistant to stem and leaf rust, and tolerant to Septoria, bunt, loose smut, and ergot. Test weight is high.

Olaf is an awned, semidwarf variety of medium maturity with good lodging resistance. It is resistant to stem and leaf rust, but susceptible to loose smut. Test weight is medium.

TRITICALE

Triticale is a new crop resulting from the crossing of wheat and rye. The crop is still in the developmental stage. The varieties currently available are not well adapted to Illinois and are usually deficient in some characteristic such as winter hardiness, seed set, or seed quality. In addition, they are of feed quality only. They do not possess the milling and baking qualities needed for use in human food.

The potential exists, however, for plant breeders to correct these deficiencies. When this is done, the crop may be especially valuable for its high protein content and high protein quality.

A limited testing program at Urbana and in DeKalb County indicates that the crop is generally lower yielding than winter wheat and spring oats. Both spring and winter types of triticale are available.

SUNFLOWERS

Two kinds of sunflowers are produced in Illinois, the oil-seed sunflower and the nonoil, or confectionary, sunflower. The oil-seed sunflower bears a relatively small seed with an oil content of 38 to 50 percent. The hull is thin and dark and adheres closely to the kernel. The oil is highly regarded as a salad oil and because of its high smoke point is unusually good for frying food and popping popcorn. The meal is used as a protein supplement in livestock rations; however, because sunflower meal is deficient in lysine, it cannot be used as the only source of protein in rations for nonruminant animals. The protein and crude fiber content vary with the method of processing. The confectionary (nonoil) sunflower bears a larger seed with a lower oil content. The hull is also lighter in color, is usually striped, and separates easily from the kernel. Confectionary sunflowers are used for human food and bird feed.

Planting. Sunflowers may be planted at the same time as corn. Because many of the hybrids offered for sale in Illinois reach physiological maturity (25 to 30 percent moisture) in 90 to 100 days, they can also follow small grain plantings as second crops. Since sunflowers do not host the soybean cyst nematode, they are a possible substitute for soybeans as a double crop.

Oil-seed sunflowers should be planted at a population rate that will establish 20 to 25 thousand plants per acre on soils with good water-holding capacity, and 16 to 20 thousand plants per acre on coarser-textured soils with relatively low water-holding capacity. Confectionary sunflowers should be planted at a lower population rate to insure larger seed size.

The recommended planting depth is 1½ to 2 inches, or about the same as that recommended for corn. Sunflowers perform best when planted in 20- or 30-inch rows, but planting in wider rows will also produce good yields.

Harvesting. Agronomists in North Dakota recommend harvesting after seed moisture has dropped to 18 or 20 percent. Losses are greatly reduced when sunflower attachments are used on the conventional combine head. These attachments are long pan-like guards extending from the cutter bar.

Problems. Because sunflowers are not commonly grown in Illinois, it is important to locate a market before planting a crop.

Feeding by birds can become a serious problem in any sunflower field and is most likely to occur near farmsteads and wooded areas. Insects and diseases can also damage sunflower crops. The severity of the damage will increase as the acreage of sunflowers increases in a community and will vary from season to season.

OATS

Spring Oats

To obtain high yields of spring oats, plant the crop as soon as you can prepare a seedbed. If you are planting oats after corn, you will probably want to disk the stalks; plowing will produce the highest yields but is usually impractical. If you are planting oats after soybeans, disking is usually the only preparation you will need, and it may be unnecessary if the soybean residue is evenly distributed.

Before planting, treat the seed with a fungicide or a combination such as captan plus Vitavax. Several other fungicides and combinations can be used. For more information, see your local Extension agent or contact the Department of Plant Pathology, University of Illinois, Urbana, Illinois. Seed treatment protects the seed during the germination process from seed- and soil-borne fungi.

Oats may be broadcast and disked in but will yield 7 to 10 bushels more per acre if drilled in. When drilling, plant at a rate of 2 to 2½ bushels per acre. If the oats are broadcast and disked in, increase the rate by ½ to 1 bushel per acre. Increase both rates if you do not plant legume and grass seeds with the oats.

For suggestions on fertilizing oats, see the section on soil testing and fertility.

Varieties

Benson (a protected variety)* is a white oat developed at the University of Minnesota and released in 1978. It matures 5 to 6 days later than Lang, grows 5 to 6 inches taller, and is not as resistant to lodging. Benson is resistant to smut and moderately resistant to crown rust. It is susceptible to the barley yellow dwarf virus.

Clintford was developed at Purdue from the cross of Clintland with Milford. Milford was introduced from Wales for its excellent straw strength. The grain is a light brownish white (or light yellowish white in some seasons), large, plump, and very high in test weight. Clintford has very short, stiff straw with large-diameter stems and a compact panicle that distinguishes it from other varieties grown in Illinois. It matures about 2 days later than Lang.

Dal (a protected variety)* was released by the Wisconsin Agricultural Experiment Station in 1972. It is similar to Froker in height and straw strength and matures at about the same time (about 8 days later than Lang). Dal kernels, which have a whitish color, contain about 2.5 percent more protein than other commonly grown varieties. Dal is moderately resistant to rust and smut and is susceptible to the barley yellow dwarf virus.

Froker is a yellow oat developed at the University of Wisconsin and released in 1970. It matures about a week later than Lang, grows several inches taller, and is less resistant to lodging. Froker is susceptible to leaf rust, smut, and the barley yellow dwarf virus.

Garland is a yellow oat released by the University of Wisconsin in 1962. It matures about 3 to 4 days later than Lang. It has good test weight and stands well. Garland is susceptible to smut, rust, and the barley yellow dwarf virus.

Holden is a yellow variety developed at the University of Wisconsin and released in 1967. It matures 5 to 6 days later than Lang. It is susceptible to rust and the barley yellow dwarf virus but is resistant to smut.

Jaycee is an early maturing, high-yielding variety developed at the University of Illinois and released in 1967. The grain color is light brownish to yellowish white. It produces fairly large, plump kernels. Jaycee has short straw and stands well under Illinois conditions until maturity. After maturity, it loses its strength rapidly and may lodge severely. Harvest Jaycee as soon as possible after maturity to avoid harvest losses associated with lodging. Jaycee is tolerant to the barley yellow dwarf virus. It is resistant to some, but not all, races of leaf and stem rust and also to the common races of smut.

Lang is a yellow oat released by the University of Illinois and the USDA in 1977. It matures about 1 day later than Jaycee and is similar in height. Lang is resistant to the barley yellow dwarf virus but is susceptible to smut and the rusts. Since its beard is difficult to thresh, it often produces a slightly lower weight per bushel than Otee. Lang has good lodging resistance.

Larry is a yellow oat developed at the University of Illinois. Foundation seed will be released to certified seed growers in 1981, and the variety will be commercially available after the 1981 harvest. Larry is similar to Lang in maturity, is higher in test weight, has a more attractive kernel, and is equal or superior to Lang in lodging resistance. It is also superior to Lang in resistance to the barley yellow dwarf virus but is susceptible to the newer races of rust and smut.

Marathon (a protected variety)* was developed at the University of Wisconsin and was released in 1979. It has light tan kernels. Although it matures about 9 days later than Lang and grows 8 to 10 inches taller, it has good lodging resistance. It has good crown rust and smut resistance but is susceptible to the barley yellow dwarf virus.

Moore (a protected variety)* was released by the University of Minnesota in 1979. It has white kernels, matures about 4 to 5 days later than Lang, and grows 6 to 7 inches taller. It is more susceptible to lodging than Lang and Marathon. Moore is resistant to smut, moderately resistant to crown rust, and susceptible to the barley yellow dwarf virus.

Noble (a protected variety)* was released to certified seed producers in 1974. It was developed by the Purdue University Agricultural Experiment Station and the Agri-

* See Plant Variety Protection Act, page 13.

Table 22. — Yields of Spring Oat Varieties in University of Illinois Tests

Variety	Northern Illinois Research Center				Urbana South Farm				
	1980		1978–80		1980		1979–80		
	Yield	Test weight	Yield	Test weight	Yield	Test weight	Yield	Test weight	Date headed
	bu./A.	*lb./bu.*	*bu./A.*	*lb./bu.*	*bu./A.*	*lb./bu.*	*bu./A.*	*lb./bu.*	*June*
Benson[a]	113	30	79	30	134	28	118	30	16
Clintford	96	36	64	32	106	32	95	35	13
Dal[a]	103	30	76	30	100	28	97	31	19
Froker	98	31	75	29	135	29	118	31	18
Garland	106	31	70	30	129	31	108	32	14
Holden	..	..	..	..	129	29	112	31	15
Jaycee	85	33	63	31	124	33	99	34	10
Lang	105	31	80	31	134	30	114	32	11
Larry	108	33	78	30	140	31	119	33	11
Marathon[a]	102	27	..	..	117	26	105	28	20
Moore[a]	97	30	80	29	130	29	121	31	15
Noble[a]	105	32	77	30	133	32	112	33	13
Ogle	111	30	82	30	142	29	121	31	14
Otee	92	34	70	32	125	32	94	34	12
Wright[a]	97	30	76	30	117	30	111	33	16

[a] U.S. Protected Variety — see page 13.

culture Research Service, USDA. Noble matures about 2 to 3 days later than Lang. It is resistant to the races of loose smut now prevalent in Illinois and is moderately resistant to the barley yellow dwarf virus. It has limited resistance to the rusts and is susceptible to current predominant races. It is resistant to lodging.

Ogle is a yellow oat developed at the University of Illinois. Foundation seed will be released to certified seed growers in 1981. Ogle matures 3 to 4 days later than Lang, grows 3 to 4 inches taller, and is similar to Lang in bushel weight and lodging resistance. It is superior to Lang in resistance to the barley yellow dwarf virus but is susceptible to the newer races of rust and smut.

Otee is a variety developed in Illinois and released jointly by the Illinois Agricultural Experiment Station and the USDA for planting by certified seed producers in 1973. Otee's yellow grain is higher in protein content than the grain of other varieties currently grown in Illinois. Otee matures 1 day later than Lang and has short straw and good lodging resistance. It has moderate resistance to rust and good resistance to the barley yellow dwarf virus.

Wright (a protected variety)* is a yellow oat released in 1975 by the University of Wisconsin. It matures 5 to 6 days later than Lang, grows several inches taller, and is less lodging resistant. It is moderately resistant to rust but is susceptible to smut. It has some tolerance to the barley yellow dwarf virus and Septoria leaf spot. It is resistant to crown rust and moderately resistant to stem rust. The protein content is average.

Winter Oats

Winter oats are not as winter hardy as wheat and are adapted to only the southern third or quarter of the state. U.S. Highway 50 is about the northern limit for winter oats.

Since the crop is somewhat winter tender and is not attacked by Hessian fly, planting in early September is highly desirable. Experience has shown that oats planted before September 15 are more likely to survive the winter than those planted after September 15.

The same type of seedbed is needed for winter oats as for winter wheat. The fertility program should be similar to that for spring oats. Seeding rate is 2 to 3 bushels per acre when drilled.

Norline, Compact, and Walken are sufficiently winter hardy to survive most winters in the southern third of the state.

Norline was released by Purdue University in 1960. It tends to lodge more than Walken and Compact. Compact was released by the University of Kentucky in 1968. It is short and more lodging resistant than Norline. Walken was released by the University of Kentucky in 1970. It is more lodging resistant than Norline and Compact but grows a little taller than those varieties.

* See Plant Variety Protection Act, page 13.

BARLEY

Both spring and winter barley can be grown in Illinois. Spring barley is best adapted to the northern quarter or third of the state, but it has been grown successfully as far south as Champaign County. Winter barley has been grown as far north as Will County, but it is best adapted to the southern half of the state.

Watch out for armyworms and chinch bugs. Both prefer barley to almost any other crop.

Spring Barley

Plant spring barley early — about the same time as spring oats. Drill in 1½ to 2 bushels of seed per acre. To avoid excessive lodging, harvest the crop as soon as it is ripe. Nutrient requirements for spring barley are essentially the same as for spring oats.

Varieties

All varieties included in Table 23 are approved for malting.

Since spring barley is not a large crop in Illinois, Illinois-grown seed is usually nonexistent. Therefore, farmers interested in growing spring barley will need to obtain seed from Wisconsin or Minnesota. Morex, Larker, Manker, Glenn, and Beacon are all grown in those states, Morex and Larker being the most popular varieties.

Table 23. — Spring Barley Performance, DeKalb

Variety	1980 Yield	1980 Test weight	1978–80 Yield	1978–80 Test weight	Date headed
	bu./A.	*lb./bu.*	*bu./A.*	*lb./bu.*	*June*
Beacon	52	44	54	44	9
Bonanza	67	45	60	45	11
Conquest	57	44	57	44	10
Glenn	54	43	60	44	9
Karl	65	44	63	45	11
Larker	54	46	54	47	10
Manker	56	46	59	46	9
Morex	60	45	56	45	9

Larker was developed at North Dakota State University and was released in 1961. It is a 6-row, semismooth-awn variety with a white aleurone. It is more susceptible to lodging than Morex but has a higher test weight.

Morex was released by the University of Minnesota in 1978. It has semismooth awns, a colorless aleurone, and a 6-row spike. Morex matures about 1 day earlier than Larker and grows to about the same height, but it is more resistant to lodging.

Winter Barley

Winter barley is not as winter hardy as the commonly grown varieties of winter wheat. For this reason, winter barley should be planted about ten days to two weeks earlier than winter wheat. Sow with a drill and plant at the rate of 2 bushels of seed per acre.

The nutrient requirements for winter barley are similar to those for winter wheat except that less nitrogen will be required. Most winter barley varieties are less resistant to lodging than winter wheat varieties. Winter barley cannot stand "wet feet"; therefore, it should not be planted on land that tends to be low and wet.

Varieties

Barsoy was developed at the University of Kentucky. It matures very early and yields well, but it is probably the least winter hardy of the varieties tested.

Harrison was developed at Purdue University and released in 1963. It grows taller than most varieties but has good straw strength. It is not quite as winter hardy as Pike and Paoli and is susceptible to the barley yellow dwarf virus.

Maury was developed by the Virginia Agricultural Experiment Station and released in 1977. Although it matures 4 to 5 days later than Pike and grows 3 to 5 inches taller, it has better lodging resistance. Maury is tolerant to the barley yellow dwarf virus, which is a serious threat to winter barley production in southern

Table 24. — Winter Barley Performance

Variety	Brownstown Research Center 1980 Yield	1980 Test weight	1980 Lodging	1979–80 Yield	1979–80 Test weight	1979–80 Average height	Urbana Research Center 1980 Yield	1980 Test weight	1979–80 Yield	1979–80 Test weight	1979–80 Lodging	1979–80 Date headed
	bu./A.	*lb./bu.*	*percent*	*bu./A.*	*lb./bu.*	*inches*	*bu./A.*	*lb./bu.*	*bu./A.*	*lb./bu.*	*percent*	*May*
Barsoy	91	48	0	60	49	32	80	49	85	50	5	15
Harrison	79	47	0	65	48	37	80	47	87	48	0	20
Maury	79	46	0	69	46	34	87	44	91	45	0	19
Monroe	90	45	0	64	46	34	79	47	83	47	0	20
Paoli	75	45	17	66	48	33	86	47	72	46	42	16
Pike	85	46	2	66	48	32	77	46	85	47	13	15

Illinois. Although Maury is not as winter hardy as Paoli, it should survive all but the most severe winters.

Monroe was released by the Virginia Agricultural Experiment Station in 1976. It was selected from the same cross as Maury and carries the same tolerance to the barley yellow dwarf virus. Like Maury, Monroe is not as winter hardy as Paoli but should still survive all but the most severe winters. It matures 1 to 2 days later than Maury.

Paoli (a protected variety)* was developed at Purdue University and released in 1971. It matures 1 to 2 days later than Pike and is equal to Pike in winter hardiness, but it is not quite as resistant to lodging.

Pike (a protected variety)* was released by Purdue University in 1975. It matures as early as Barsoy and is more winter hardy.

* See Plant Variety Protection Act, page 13.

GRAIN SORGHUM

While grain sorghum can be grown successfully throughout Illinois, its greatest potential is in the southern third of the state. It is adapted to almost all soils, from sand to heavy clay. Its greatest advantage over corn is tolerance of moisture extremes. Grain sorghum usually yields more than corn when moisture is in short supply, though it seldom yields as much as corn under optimum conditions.

Fertilization. Nutrient requirements for sorghum are similar to those of corn. Since the response to nitrogen has been erratic, maximum rate of nitrogen suggested is about 125 pounds. Sorghum is sensitive to salt, and seeds should not be placed in direct contact with starter fertilizer.

Planting. Sorghum should not be planted until soil temperature is 65°F. or above. In the southern half of the state mid-May is considered the starting date; late May to June 1 is the planting date in the northern half.

Sorghum emerges more slowly than corn and requires a relatively fine and firm seedbed. Planting depth should not exceed 1½ inches, and ¾ to 1 inch is considered best.

Population and row spacing. Row spacing experiments have shown that 20- to 30-inch rows produce far better than 40-inch rows. Four to 6 plants per foot of row in 30-inch rows at harvest and 2 to 4 plants per foot in 20-inch rows are adequate. Plant 30 to 50 percent more seeds per foot of row than the intended stand.

Weed control. Since emergence of sorghum is slow, controlling weeds presents special problems. Suggestions for chemical control of weeds are given in the back of this handbook. As with corn, a rotary hoe is useful before weeds become permanently established.

Harvesting and storage. Timely harvest is important. Rainy weather after sorghum grain reaches physiological maturity may cause sprouting in the head or weathering (soft and mealy grain), or both.

Marketing. Before planting, check on local markets. Because of limited acreage in Illinois, many elevators do not purchase grain sorghum.

Grazing. After harvest, sorghum stubble can be used for pasture. Livestock should not be allowed to graze for one week after frost, since the danger of prussic acid or hydrocyanic acid (HCN) poisoning is especially high. Newly frosted plants sometimes develop tillers high in prussic acid.

CROPS FOR LATE PLANTING

In most years, flooding or some other disaster makes replanting of corn and soybeans necessary somewhere in Illinois.

When this happens, the most common questions are (1) is it too late to replant with corn or soybeans? (2) if it is not too late, how early a variety should be used? and (3) if it is too late for corn or soybeans, is there any other crop that can be substituted for feed-grain or cash-grain production?

Any answer to these questions assumes that (1) weather conditions following replanting will favor immediate germination and emergence, (2) rainfall and temperatures will favor normal growth and development, and (3) the first killing frost in the fall will be as late or later than average.

The following are estimates of how late corn and soybeans may be planted in Illinois.

In the northwestern corner of the state, where the first killing frost can be expected before October 5, June 15 is the latest date that early varieties of corn can be planted with reasonable assurance that they will be mature (30 to 35 percent moisture) before the first frost. Make the shift to early varieties in late May.

As the average date of the first killing frost moves later into October, the latest date for planting corn for grain moves later into June. In the northern third of the state, you can move the planting date later into June about the same number of days that the first frost falls after October 5. In the southern two-thirds of the state (this is especially true of the southern third), you can move the planting date proportionally later into June because temperatures will be higher during the remainder of the growing season.

In central Illinois, where the average killing frost occurs on October 15, early varieties of corn planted as late as July 5 have a 50-percent chance of maturing before frost. In southern Illinois, corn planted later in July usually will mature. However, planting later than July 5 to 10 is of questionable merit unless the need for grain or silage is especially great.

When corn planting is delayed past June 1 to 10, consider soybeans or sorghum as alternatives. These crops usually yield better than late-planted corn.

The vegetative period of soybeans is shortened as planting is delayed. Thus, soybeans can be planted later than corn with reasonable assurance that they will mature before frost. In northern Illinois, where the first killing frost is expected about October 5, early varieties, such as Chippewa 64 and Hark, may be expected to mature when planted as late as the end of June. The later varieties, such as Harcor and Corsoy, may be used until the middle of June.

In north central Illinois, you can plant Harcor and Corsoy until early July and you can use varieties of the maturity of Beeson until mid-June. In central Illinois, Wayne and varieties of similar maturity will mature when planted by mid-June. Use Amsoy 71, Corsoy, and Harcor until July 5 to 10. The growing season in southern Illinois is long enough that most of the varieties normally grown in the area will mature when planted as late as July 5 to 10.

When you must plant soybeans late, use the tallest variety that has a reasonable chance to mature. One of the problems with late-planted soybeans is short plant height with low podding. Dry weather aggravates this problem.

Other grain crops that mature in a short time and can be used in an emergency are sorghum and buckwheat.

Varieties of sorghum that will mature in 90 to 100 days are sometimes used for late planting. The penalty for planting sorghum late is often not as great as it is for corn and other crops.

If the crop is being grown as a cash crop, arrangements for a market should be made before planting. Some elevators prefer not to handle sorghum. Local livestock feeders or feed mills may be interested in the crop. Drying the grain is another problem often associated with sorghum. The grain should be harvested as soon as it is mature. Often this will be before the plant is dry, and the grain will be too wet to store without drying.

Buckwheat may mature in 75 to 90 days. It can be planted as late as July 10 to 15 in the northern part of the state and late July in southern Illinois. The crop is sensitive to both cold and hot weather. It will be killed by the first frost in the fall. Yields will be disappointingly low if it blooms during hot weather.

The market for buckwheat is limited unless you plan to use it for livestock feed. Be sure of a market before you plant it.

For more detailed treatment, see Circular 1181, *Crops for Emergency Planting.*

HAY, PASTURE, SILAGE, AND SEED POLLINATION

High Yields

Thick, vigorous stands of grasses and legumes are needed for high yields. A thick stand of grass will cover nearly all the ground. A thick stand of alfalfa is about 30 plants per square foot in the seeding year, 10 plants per square foot the second year, and 5 plants per square foot for succeeding years.

Vigorous stands are created and maintained by choosing disease- and insect-resistant varieties that grow and recover quickly after harvest, fertilizing adequately, harvesting at the optimum time, and protecting the stand from insects.

Establishment

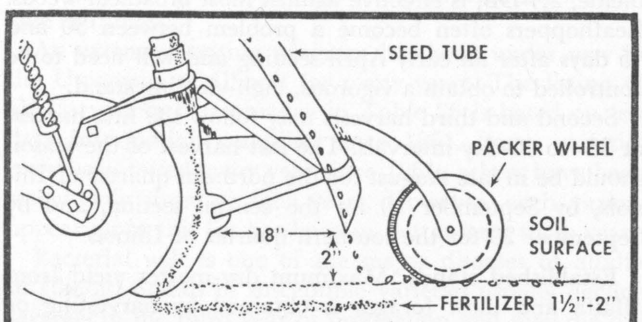
Spring seeding date for hay and pasture species in Illinois is late March or early April as soon as a seedbed can be prepared. An exception is when seedings are made in a fall-seeded winter annual companion crop. In winter annual companion crops, hay and pasture species should be seeded about the time of the last snow.

Spring seedings in spring oats should be done at the time the oats are seeded.

Spring seedings are more successful in the northern half of Illinois than in the southern half. The frequency of success in the southern one-quarter to one-third of the state indicates late-summer seedings may be more desirable than spring seedings. Spring seedings are usually more successful than late-summer seedings in the northern quarter of Illinois.

Late-summer seeding date is August 10 in the northern quarter of Illinois, August 30 in central Illinois, and September 15 in the southern quarter of Illinois. Seedings should be made close to these dates and not more than five days later to assure that the plants become well established before winter.

Seeding rates for hay and pasture mixtures are shown in Table 33 on page 29. These rates are for average conditions and when seeded with a companion crop in the spring or without a companion crop in late summer.



Placement of high-phosphate fertilizer with grain drill. (Fig. 2)

Table 25. — Seeding Method of Alfalfa in Illinois

Years	Band[a] Average tons dry matter per acre per year	Broadcast[a] Average tons dry matter per acre per year
1959, Urbana	6.44	5.73
1967-70, Urbana	5.38	5.56
1967-70, DeKalb	4.57	4.48
1967-68, Brownstown	3.11	2.92

[a] Seeding rate of 12 pounds per acre.

Higher rates can be used to obtain high yields from alfalfa seeded without a companion crop in the spring. Higher seeding rates than described in Table 33 have proven economical in northern and central Illinois when alfalfa was seeded as a pure stand in early spring and two or three harvests in the seeding year were taken. Seeding alfalfa at 18 pounds per acre has produced 0.2 to 0.4 ton higher yield than seeding at 12 pounds per acre in northern and central Illinois, but not in south-central Illinois.

The two basic methods of seeding are band seeding and broadcast seeding. Band seeding is placing a band of phosphate fertilizer (0-45-0) about two inches deep in the soil with a grain drill, then placing the forage seed on the soil surface directly above the fertilizer band. The fertilizer should be covered with soil before the forage seeds are dropped. This process occurs naturally when soils are in good working condition. A press-wheel should roll over the forage seed to firm the seed into the soil surface. Many seeds will be placed one-fourth to one-half inch deep with this seeding method (Fig. 2).

Broadcast seeding is spreading the seed uniformly over the prepared soil surface, then pressing the seed into the soil surface with a corrugated roller. The fertilizer is applied at the early stages of seedbed preparation. The seedbed is usually disked and smoothed with a harrow. Most soil conditions are too loose after these tillage operations and should be firmed with a corrugated roller before seeding. The best seeding tool for broadcast seeding is the double corrugated roller-seeder.

Which is the better seeding method? Illinois studies have shown that band seeding resulted in higher alfalfa yields than broadcast seedings for August and spring seedings at most locations (Table 25). Seedings on a low phosphorus-supplying soil had a higher yield from band seeding than broadcast seeding (Brownstown). Early seeding on a cold, wet soil was favored by banded phosphorus fertilization (DeKalb). The greater yield from band seeding may be a response to abundant, readily available phosphorus from the banded fertilizer. Broadcast seedings were higher yielding at Urbana in one trial, probably because the silt loam soils were medium in phosphorus-supplying capacity and are better drained and warmer than the silty clay loam at the DeKalb field.

Forage crop seeds are small and should be seeded no deeper than one-fourth to one-half inch. These seeds need to be in close contact with soil particles. The double corrugated roller-seeder and the band seeder with press wheels roll the seed into contact with the soil and are the best known methods of seeding forages.

Fertilizing and Liming Before or at Seeding

Lime. Apply lime at rates suggested in Figure 6, page 33. If rate requirements are in excess of 5 tons, apply half before the primary tillage (in most cases, plowing) and half before the secondary tillage (harrowing, disking). Apply rates of less than 5 tons at one time, preferably after plowing, but either before or after is acceptable.

Nitrogen. No nitrogen should be applied for legume seedings on soils above 2.5 percent organic matter. Up to 20 pounds per acre may help assure rapid seedling growth of legume-grass mixtures on soils with less than 2.5 percent organic matter. In the seedings of a pure grass stand, 50 to 100 pounds nitrogen per acre in the seedbed is suggested. If band seeding, apply nitrogen with phosphorus through the grain drill. For broadcast seedings, apply broadcast with phosphorus and potassium.

Phosphorus. Apply all phosphorus at seeding time (Tables 46 and 48) or broadcast part of it with potassium. For band seeding, reserve a minimum of 30 pounds of P_2O_5 per acre. For broadcast seeding, broadcast all the phosphorus with potassium, preferably after primary tillage and before final seedbed preparation.

Potassium. Fertilize before or at seeding. Broadcast application of potassium is preferred (Tables 47 and 48). For band seeding, you may safely apply a maximum of 30 to 40 pounds K_2O per acre in the band with phosphorus. The response to band fertilizer will be mainly from phosphorus unless the K soil test is very low (perhaps 100 or less). For broadcast seeding, apply all the potassium after the primary tillage. You can apply up to 600 pounds of K_2O per acre in the seedbed without damaging seedlings if the fertilizer is incorporated.

Fertilization

Nitrogen. See pages 41 and 42.

Phosphorus. This nutrient may be applied in large amounts, adequate for two to four years. The annual needs of a hay or pasture crop are determined from yield and nutrient content of the forage harvested (Table 48). Grasses, legumes, and grass-legume mixtures contain about 12 pounds of P_2O_5 (4.8 pounds of P) per ton of dry matter. Total annual fertilization needs include any needed build-up rate (Table 46) and the maintenance rate (Table 48).

Potassium. Grasses need large amounts of potassium to balance high rates of nitrogen fertilization, since potassium helps the plant convert nitrogen to protein. As nitrogen rates are increased, the percent nitrogen in the plant tissue also increases. However, if potassium is deficient, some nitrogen may remain in the plant as nonprotein nitrogen.

Legumes feed heavily on potassium. Potassium, a key element in maintenance of legumes in grass-legume stands, is credited with improving winter survival.

Annual potassium needs are determined from yield, nutrient content in the forage that is harvested, and nutrient build-up requirements of a particular soil (Tables 47 and 48). Grasses, legumes, and grass-legume mixtures contain about 50 pounds of K_2O (41.5 pounds of K) per ton of dry matter.

Boron. Symptoms of boron deficiency appear on second and third cuttings of alfalfa during drought periods in some areas of Illinois. But yield increases from boron fertilization have been infrequent. There is no recommendation for general application of boron in Illinois. If you suspect that there is a boron deficiency, topdress a test strip in your alfalfa fields with 30 pounds per acre of household borax (3.3 pounds of actual boron). For general application, have boron added to the phosphorus-potassium fertilizer.

Management

Seeding year. Hay crops and pastures spring-seeded in a companion crop will benefit by early removal of the companion crop. Oats, wheat, or barley should be removed when the grain is in the milk stage. If these small grains are harvested for grain, it is important to remove the straw and stubble as soon as possible. As small grain yields increase, greater competition is being expressed on underseeded legumes and grasses, and fewer satisfactory stands are being established by the companion crop method. Forage seedings established with a companion crop may have one harvest taken by late August in northern Illinois and occasionally two harvests by September 10 in central Illinois and by September 25 in southern Illinois.

Spring-seeded hay crops and pastures without a companion crop should be ready for harvest 65 to 70 days after an early April seeding. Weeds very likely will need to be controlled about 30 days after seeding unless a preemergence herbicide was used. A postemergence herbicide, 2,4-DB, is effective against most broadleaf weeds. Leafhoppers often become a problem between 30 and 45 days after an early April seeding and will need to be controlled to obtain a vigorous, high-yielding stand.

Second and third harvests may follow the first harvest at 35- to 40-day intervals. The last harvest of the season should be in late August for the northern quarter of Illinois, by September 10 for the central section, and by September 20 for the southern quarter of Illinois.

Established stands. Maximum dry-matter yield from alfalfa and most forages is obtained by harvesting or grazing the first cutting at nearly full bloom and harvesting every 40 to 42 days thereafter until September. This management produces a forage that is relatively low in digestibility. It is suitable for livestock on maintenance, will produce slow weight gain, and can be used in low-production feeding programs. High performance feeding programs need a highly digestible forage. The optimum compromise between high digestibility and dry-matter yield of alfalfa is to harvest or graze the first cutting at the late-bud-to-first flower stage and to make subsequent cuttings or grazings at 35-day intervals. Rotational grazing is essential to maintain legumes in pastures. A rotational grazing program should provide for 5 to 7 days of grazing and 30 to 35 days of rest.

Winter survival and vigor of spring growth are greatly affected by the time of the fall harvest. A high level of root reserves (sugars and starches) is needed. Root reserves decline following a harvest as new growth begins. About three weeks after harvesting, root reserves are depleted to a low level and the top growth is adequate for the photosynthesis to support the plant's needs for sugars. Root reserves are replenished gradually from this point until harvested, or until the plant becomes dormant in early winter. Harvests made in September and October affect late-fall root reserves of alfalfa more than do harvests made in the summer. After the September harvest, alfalfa needs a recovery period lasting until late October to restore root reserves. On well-drained soils in central and southern Illinois, a "late" harvest may be taken after plants have become dormant in late October.

Species and Varieties

Alfalfa is the highest yielding perennial forage crop suited to Illinois, and its nutritional qualities are nearly unsurpassed. Alfalfa is an excellent hay crop species and can be used in pastures with proper management as mentioned above.

Bloat in ruminant animals often is associated with alfalfa pastures. Balancing soil fertility, including grasses in mixtures with alfalfa, maintaining animals at good nutritional levels, and using bloat-inhibiting feed amendments are methods to reduce or essentially eliminate the bloat hazard.

Many varieties of alfalfa are available. Some have been privately developed; some have been developed at public institutions. Private varieties usually are marketed through a few specific dealers. Not all varieties are available in Illinois.

An extensive testing program has been under way at the University of Illinois for many years. The listing of alfalfa variety performance in Table 26 is based on test data information compiled since 1961. Some varieties have been tested every year since 1961; others have been tested only three or four years. However, each variety appearing in this list has been in test at least three years.

Bacterial wilt is one of the major diseases of alfalfa in Illinois. Stands of susceptible varieties usually decline severely in the third year of production and may die out in the second year under intensive harvesting schedules. Moderate resistance to bacterial wilt enables alfalfa to persist up to four or five years. Varieties listed as resistant usually persist beyond five years.

Other diseases and insects are problems and some varieties have particular resistance to these problems. You should question your seed supplier concerning these attributes of the varieties being offered to you.

Red clover is the second most important hay and pasture legume in Illinois. It does not have the yield potential of alfalfa under good production conditions, but can persist in more acid soil conditions and under more shade competition than alfalfa. Although red clover is physiologically a perennial, root and crown diseases limit the life of red clover to two years. New varieties,

Table 26. — Leading Alfalfa Varieties Tested Three Years or More in Illinois

Variety	Bacterial wilt	Percentage of yield of check varieties: Northern Illinois	Central Illinois	Southern Illinois
Agate	R[a]	99	102	...
Answer	R	109[b]	109	101[b]
Apollo	R	105	107	104
Aquaris	R	102	106	104
Arc	MR[c]	103	105	102
Atlas	R	111	109	...
A-54	R	109[d]	109	106
Baker	R	95	107	97
Blazer	R	115	108	125[d]
Citation	R	113	98	...
DeKalb Brand 120	R	116	112	112[b]
DeKalb Brand 130	R	109	110	118[b]
Discovery	R	106	102	105
Dominor	R	105	102	111
Gladiator	R	101	106	108
G-7730	R	110	109	114[d]
Honeoye	R	108	103	105
Iroquois	R	106	98	100
Magnum	R	108	109	112[b]
Marathon	R	112	102	105
Olympic	R	108	109	108[b]
Pacer	R	110	106	...
Peak	R	115	110	...
Polar I	R	106	103	105
Primal	R	108	103	102
Saranac	R	106	103	102
Saranac AR	R	108	109	105
Tempo	R	107	99	105
Thor	R	108	100	102
Trident	R	106[b]	106	114[b]
Vangard	R	107	108	101
Voris A-77	R	108	108	109
Weevlchek	R	106	102	103
WL 215	R	106	104	103
WL 219	R	108	104	106
WL 220	R	105	106[b]	110[b]
WL 311	R	110	108	107
WL 312	R	111	107	116[b]
WL 318	R	102	106	103
520	R	107	105	111
521	R	106	102	103[b]
524	R	111	107	109
531	R	105	109	113
545	R	101	102	96

[a] R = resistant.
[b] Data for 2 years only.
[c] MR = moderately resistant.
[d] Data for 1 year only.

including Arlington, Kenstar, and Redland, have increased resistance to root and crown diseases and are expected to be productive for at least three years. See Table 27.

Red clover does not have as much seedling vigor or as rapid a seedling growth rate as alfalfa. Therefore, red clover does not fit into a spring seeding without a companion crop program as well as alfalfa.

Red clover has more shade tolerance at the seedling stage than alfalfa. Therefore, red clover is recommended for most pasture renovation mixtures where shading by existing grasses occurs.

There are fewer varieties of red clover than of alfalfa. Many are from the U.S. Department of Agriculture and state experiment stations. Private breeders are also active in red clover variety development.

Mammoth red clover is being grown on about 17 percent of the clover acreage. Yields of mammoth red clover have been lower than yields of most of the improved varieties of medium red clover.

Ladino clover is an important legume in pastures, but it has received little attention recently because of its short-lived character. The very leafy nature of ladino makes it an excellent legume for swine. It is a very high-quality forage for ruminant animals also, but problems of bloat frequently are experienced.

Ladino lacks drought tolerance because its root system is shallower than that of red clover or alfalfa.

Birdsfoot trefoil has been popular in permanent pastures in northern Illinois. It has a long life but becomes established very slowly. Seedling growth rate is much slower than that of alfalfa or red clover.

A root rot has made birdsfoot trefoil a short-lived crop throughout southern Illinois. The variety Dawn may have adequate resistance to persist throughout the state.

Rooting depth of birdsfoot trefoil is shallower than alfalfa. Thus birdsfoot trefoil is not as productive during drought.

Crownvetch is well known for protecting very erosive soil areas. As a forage crop, crownvetch is much slower in seedling emergence, seedling growth rate, early season growth, and recovery growth than alfalfa or red clover. Growth rate is similar to that of birdsfoot trefoil. The potential of crownvetch as a hay or pasture plant seems restricted to very rough sites and soils of low productivity.

Sainfoin is a legume introduced into the western United States from Russia. This species has failed to become well enough established in Illinois tests to make valid comparisons with alfalfa, red clover, and others. Observations indicate that sainfoin has a slow growth and recovery growth rate and is not well suited to the humid conditions of Illinois.

Hairy vetch is an annual legume that has limited value as a hay or pasture species. Low production and its viny nature have discouraged much use. Hairy vetch may reseed itself and become a weedy species in small grain fields.

Table 27. — Red Clover Variety Average Yields, 1976-77

Variety	Anthracnose resistance	Amount of dry matter		
		DeKalb	Urbana	Browns-town
		Tons per acre		
Arlington	Northern	4.15	4.28	2.43
Clovage	Northern	3.36	3.70	1.97
E-688	Southern	3.63	4.22	2.35
Florex	Northern	4.34	4.10	2.09
Florie	Northern, Southern	3.98	4.42	2.45
Ruby	Northern	3.99	4.46	2.34
Kenland	Southern	3.32	4.26	2.32
Kenstar	Southern	3.60	4.32	2.08
Lakeland	Northern	3.81	3.88	2.15
Redland	Northern, Southern	3.68	4.32	2.38
Redman	Northern	4.29	4.23	2.18

Table 28. — Birdsfoot Trefoil Variety Yields, 1980

Variety	Amount of dry matter	
	DeKalb	Urbana
	Tons per acre	
Carroll	3.90	5.14
Dawn	3.67	4.83
Empire	3.83	4.67
Fargo	3.77	4.22
Leo	3.98	5.44
Missouri-20	4.26	5.92
Viking	3.87	5.43

Table 29. — Timothy Variety Yields, 1979–80

Variety	Amount of dry matter			
	DeKalb	Urbana	Browns-town	Dixon Springs
	Tons per acre			
FS 954	3.99	4.41	...	2.35
FS 955	3.83	4.03	...	2.28
Itasca	3.69	4.62	5.08	2.60
Pronto	3.33	3.59	5.33	2.39
Toro	3.87	4.49	5.95	2.86

Lespedeza is a popular annual legume in the southern third of Illinois. It comes on strong in mid-summer when most other forage plants are at their low ebb in production. It survives on soils of low productivity and is low yielding. It does not produce as well as a good stand of alfalfa even in mid-summer, nor will it encroach on a good alfalfa stand. As alfalfa or other vigorous pasture plants fade out of a pasture, lespedeza may enter.

Timothy is the most popular hay and pasture grass in Illinois. Timothy is not as high yielding and has less mid-summer production than smooth bromegrass. It is a cool season species and is best suited to the northern half of Illinois. There are promising new varieties (Table 29).

Smooth bromegrass is probably the most widely adapted, high-yielding grass species for northern and central Illinois. Smooth bromegrass combines well with alfalfa or red clover. It is productive, but it has limited summer production when moisture is lacking and temperatures are high. It produces well in spring and fall and can utilize high-fertility programs. There are a few improved varieties, and breeding work continues (Table 30).

Orchardgrass is one of the most valuable grasses for hay and pasture use in Illinois. It is adapted throughout the state, being marginally winter hardy for the northern quarter of the state. Orchardgrass heads out relatively early in the spring and thus should be combined with early flowering alfalfa varieties. Orchardgrass is one of the more productive grasses in mid-summer. It is a high-yielding species and several varieties are available (Table 31).

Reed canarygrass is not widely used, but it has growth attributes that deserve consideration. Reed canarygrass is the most productive of the tall perennial grasses that are well suited to Illinois hay and pasture lands. It tolerates wet soils but also is one of the most drought-resistant grasses and can utilize high fertility. It is coarser than orchardgrass or bromegrass but not as coarse as tall fescue. Grazing studies indicate that reed canarygrass will produce good gains equal to those of bromegrass, orchardgrass, or tall fescue under proper grazing management. Reed canarygrass should be considered for grazing during spring, summer, and early fall. Cool temperatures and frost retard growth and induce dormancy earlier than with tall fescue, smooth bromegrass, or orchardgrass.

Tall fescue is a popular grass for beef cattle in southern Illinois. It is especially useful for winter pasture. Tall fescue is most palatable during spring and late fall. Summer production and palatability are low. Tall fescue is a high-yielding grass, outstanding in performance when used properly. Tall fescue is marginally winter hardy for the northern quarter of the state.

Sudangrass, sudangrass hybrids, and sorghum-sudangrass hybrids are annual grasses that are very productive in late summer. These grasses need to be seeded each year on a prepared seedbed. The total season production from these grasses may be less than that from perennial grasses with equal fertility and management. However, these annual grasses fill a need for quick, supplemental pastures as green feed. These tall, juicy grasses are difficult to make into high-quality hay. Sudangrass and sudangrass hybrids have finer stems than the sorghum-sudan hybrids and thus will dry more rapidly; they should be chosen for hay purposes over the sorghum-sudan hybrids. Crushing the stems with a hay conditioner will help speed drying.

Millets are warm season annual grasses that are drought tolerant. Four commonly known millets are pearlmillet (*Pennisetum typhoides*), browntop millet (*Panicum ramosum*), foxtail or Italian millet (*Setaria italica*), and Japanese millet (*Echinochloa crusgalli*). Pearlmillet has been evaluated in grazing trials and is a suitable alternative for summer annual pastures.

Table 30. — Smooth Bromegrass Variety Yields, 1979–80

Variety	Amount of dry matter			
	DeKalb	Urbana	Browns-town	Dixon Springs
	Tons per acre			
Barton	3.71	3.95	5.22	2.23
Baylor	3.82	4.45	5.30	2.23
Blair	4.23	4.36	5.11	2.38
Fox	3.52	3.81	4.52	1.87
FS Beacon	3.86	4.03	4.93	2.01
Regro	...	...	5.00	1.90
Sac	3.47	4.03	4.71	2.10

Table 31. — Orchardgrass Variety Yields, 1979–80

Variety	Amount of dry matter			
	DeKalb	Urbana	Browns-town[a]	Dixon Springs[a]
	Tons per acre			
Able	3.08	3.52	4.85	2.57
Crown	3.29	3.63	5.44	2.61
Dart	3.54	3.89	5.47	2.92
FS 863	3.00	3.76	5.38	3.02
Hallmark	3.56	3.72	5.44	2.87
Hawk	...	...	5.40	...
Lotto	3.04	3.74	...	2.10
Potomac	2.89	3.83	5.33	2.40
Sterling	3.64	3.93	5.28	2.78

[a] Data for 1980 only.

Pearlmillet requires a warmer soil for rapid establishment than does sudangrass. Seedings should be delayed until the soil temperature in the seedbed averages 70°F.

Pearlmillet does not have a prussic acid potential as does sudangrass, nor is pearlmillet as susceptible to leaf diseases. Pearlmillet is more drought tolerant than sudangrass, thus producing more pasture during hot dry periods of late summer than does sudangrass.

Forage Mixtures

Mixtures (Table 33) of legumes and grasses usually are desired. Yields tend to be greater with mixtures than with either the legume or the grass alone. Grasses are desirable additions to legume seedings to fill in where the legume ceases to grow, to reduce the bloat hazard with ruminant animals, to reduce late winter-heaving damage, to increase the drying rate, and perhaps to improve animal acceptance. Mixtures of two or three well chosen species are usually higher yielding than mixtures of five or six species in which some of the species are not particularly well suited to the soil, climate, or use.

Table 32. — Hay, Pasture, and Silage Crop Varieties

Crop	Variety	Origin	Use
Ladino clover	Merit	Iowa	Pasture
Birdsfoot trefoil	Carroll	Iowa	Hay and pasture
	Dawn	Missouri	Pasture
	Empire	New York	Pasture
	Fargo	North Dakota	Hay and pasture
	Leo	Canada	Hay and pasture
	Missouri-20	Missouri	Hay and pasture
	Viking	New York	Hay and pasture
Crownvetch	Chemung	New York	Erosion and pasture
	Emerald	Iowa	Erosion and pasture
	Penngift	Pennsylvania	Erosion and pasture
Smooth bromegrass	Barton	Land O'Lakes, Inc.	Hay and pasture
	Baylor	Rudy Patrick Company	Hay and pasture
	Blair	Rudy Patrick Company	Hay and pasture
	Fox	Minnesota	Hay and pasture
	FS Beacon	Land O'Lakes, Inc.	Hay and pasture
	Lincoln	Nebraska	Hay and pasture
	Saratoga	New York	Hay and pasture
	Sac	Wisconsin	Hay and pasture
	Southland	Oklahoma	Hay and pasture
Orchardgrass	Able	Farm Forage Research Cooperative	Hay and pasture
	Boone	Kentucky	Hay and pasture
	Crown	North American Plant Breeders	Hay and pasture
	Dart	Land O'Lakes, Inc.	Hay and pasture
	Dayton	Rudy Patrick Company	Hay and pasture
	FS 863	FS Services	Hay and pasture
	Hallmark	Farm Forage Research Cooperative	Hay and pasture
	Hawk	North American Plant Breeders	Hay and pasture
	Ina	Northrup, King and Company	Hay and pasture
	Jackson	Virginia	Hay and pasture
	Lotto	Holland	Hay and pasture
	Napier	Rudy Patrick Company	Hay and pasture
	Pennlate	Pennsylvania	Hay and pasture
	Potomac	Maryland	Hay and pasture
	Sterling	Iowa	Hay and pasture
Tall fescue	Alta	Oregon	Pasture
	Aronde	Holland	Pasture
	Balade	Holland	Pasture
	Fawn	Oregon	Pasture
	Forager	Farm Forage Research Cooperative	Pasture
	Kenmont	Kentucky	Pasture
	Kenhy	Kentucky	Pasture (more palatable)
	Kenwell	Kentucky	Pasture (more palatable)
	Ky-31	Kentucky	Pasture
	Mo-96	Missouri	Pasture (more digestible)
	Pastuca	Holland	Pasture
Timothy	Clair	Kentucky	Hay
	Climax	Indiana	Hay
	FS 954	FS Services	Hay
	FS 955	FS Services	Hay
	Itasca	Minnesota	Hay
	Pronto	Pride Company, Inc.	Hay
	Timfor	Northrup, King and Company	Hay
	Toro	Rudy Patrick Company	Hay
	Verdant	Wisconsin	Hay

Pasture Renovation

Pasture renovation usually involves establishing a new species in an existing pasture. Plants most commonly chosen for interseeding are legumes such as alfalfa, red clover, and birdsfoot trefoil. The seeds are planted into the existing sod using a no-till seeder, and the existing grass is then severely "set back" to give the new species time to germinate and successfully compete for light, moisture, and nutrients.

Pasture renovation programs are most successful when the soil fertility is improved so that the pH is 6.5 or more, the P_1 level is 40 pounds per acre or more, and the K level is 300 pounds per acre or more. Applying some starter fertilizer (25N-50P_2O_5-100K_2O lb./acre) is also beneficial. To set back the existing grass, the pasture should be grazed very short for 3 or 4 weeks just before seeding, and a grass-killing herbicide (such as Paraquat or Roundup) should be applied 1 or 2 days

Table 33. — Forage Seed Mixture Recommendations, All Entries Given in Pounds per Acre

For Hay Crops

Central, Northern Illinois		Central, Southern Illinois	
Moderate to well-drained soils			
Alfalfa	12	Alfalfa Orchardgrass	8 6
Alfalfa Bromegrass	8 6	Alfalfa Tall fescue	8 6
Alfalfa Bromegrass Timothy	8 4 2		
Alfalfa Timothy	8 4		
Poorly drained soils			
Alsike clover Timothy	5 4	Reed canarygrass Alsike clover	8 4
Reed canarygrass Alsike clover	8 3	Tall fescue Alsike clover	6 4
Birdsfoot trefoil Timothy	5 2	Redtop Alsike clover	4 4
Droughty soils			
Alfalfa Bromegrass	8 6	Alfalfa Orchardgrass	8 4
Alfalfa Tall fescue[a]	8 6	Alfalfa Tall fescue	8 6
		Alfalfa Bromegrass	8 6

For Horse Pastures

Central, Northern Illinois		Southern Illinois	
Moderate to well-drained soils			
Alfalfa Smooth bromegrass Kentucky bluegrass	8 6 2	Alfalfa Orchardgrass Kentucky bluegrass	8 3 5
Poorly drained soils			
Smooth bromegrass Kentucky bluegrass Timothy Ladino clover	6 2 2 ½	Orchardgrass Kentucky bluegrass Ladino clover	6 5 ½

Central Illinois	
Moderate to well-drained soils	
Alfalfa Orchardgrass Kentucky bluegrass	8 3 2
Poorly drained soils	
Orchardgrass Kentucky bluegrass Ladino clover	6 2 ½

For Pasture Renovation

Central, Northern Illinois		Southern Illinois	
Moderate to well-drained soils			
Alfalfa Red clover	8 4	Alfalfa Red clover	8 4
Poorly drained soils			
Birdsfoot trefoil Red clover	4 4	Alsike Ladino clover Red clover	2 ½ 4

For Rotation and Permanent Pastures

Central, Northern Illinois		Southern Illinois	
Moderate to well-drained soils			
Alfalfa Bromegrass Timothy	8 5 2	Alfalfa Orchardgrass	8 4
Alfalfa Orchardgrass[a]	8 4	Alfalfa Tall fescue	8 6
Alfalfa Orchardgrass[a] Timothy	8 4 2	Tall fescue Ladino clover	8 ½
Orchardgrass[a] Ladino clover	6 ½	Alfalfa Bromegrass Timothy	8 6 2
Red clover Ladino clover Orchardgrass[a]	8 ½ 4	Orchardgrass Ladino clover	6 ½
Red clover Ladino clover Tall fescue	8 ½ 6-8	Tall fescue	10
Birdsfoot trefoil Timothy	5 2	Orchardgrass	8
Bromegrass Ladino clover	8 ½	Red clover Ladino clover Orchardgrass	8 ½ 4
Tall fescue	10	Red clover Ladino clover Tall fescue	8 ½ 6-8
Orchardgrass[a]	8		
Poorly drained soils			
Alsike clover Ladino clover Timothy	3 ¼ 4	Alsike clover Tall fescue Ladino clover	2 8 ½
Birdsfoot trefoil Timothy	5 2	Reed canarygrass Alsike clover Ladino clover	8 3 ½
Reed canarygrass Alsike clover Ladino clover	8 3 ¼-½		
Alsike clover Tall fescue Ladino clover	2 8 ½		
Droughty soils			
Alfalfa Bromegrass	8 5	Alfalfa Orchardgrass	8 4
Alfalfa Orchardgrass[a]	8 4	Alfalfa Tall fescue	8 6
Alfalfa Tall fescue	8 6	Red clover Ladino clover Orchardgrass[a]	8 ½ 4
Red clover Ladino clover Orchardgrass	8 ½ 4	Red clover Ladino clover Tall fescue	8 ½ 6-8
Red clover Ladino clover Tall fescue	8 ½ 6-8		

For Hog Pastures

All soil types, anywhere in Illinois	
Alfalfa Ladino clover	8 2

[a] Central Illinois only.

before or after seeding. If Paraquat is used, a broadleaf herbicide (such as 2,4-D) should be applied 2 weeks before seeding to remove seedling plantain, dock, and thistles. Seedings should be made in late March to early April or in late August to very early September.

Spring grazing should begin when the legumes begin to flower (late May to early June). The field should then be grazed on a rotation program of 7 to 10 days grazing and 32 to 35 days rest between grazings. Pastures seeded in late summer should not be grazed until the next spring.

Pollination of Legume Seeds

Illinois always has been an important producer of legume seeds, particularly red clover. Illinois leads the nation in seed production acreage but is second to Oregon in total seed production. The 1980 yield of 85 pounds per acre is well below the 240 pounds per acre in Oregon. The low yields are in part caused by inadequate pollination by bees. Only during the second bloom do honey bees visit red clover in high enough numbers to pollinate it while they collect pollen and nectar. In experiments on the Agronomy Farm at Urbana, honey bees collected 54 to 99 percent of their daily pollen intake from red clover between July 12 and August 3.

Bumblebees also pollinate red clover, but they cannot be relied on because they are not always present and their numbers are unpredictable. Even the presence of honey bees in the vicinity of red clover fields can no longer be assured, because hive numbers in Illinois are now estimated at only 36,000 compared with about 76,000 hives in 1970 and 140,000 in 1958.

If you produce red clover seed, do so on the second crop and use at least two colonies of honey bees per acre within or beside the field. On large fields place them in two or more groups. Do not rely on bees present in the neighborhood, because pollination and seed set decrease rapidly as distance between the hives and the crop becomes greater than 800 feet. Bring a sufficient number of hives to the field as soon as it comes into bloom. When all factors for seed production are favorable, proper pollination of red clover by honey bees has the potential of doubling or tripling seed yields.

White and yellow sweetclovers are highly attractive to bees and other insects. However, probably because of the large number of blossoms, their seed yields increase when colonies of honey bees are placed nearby. Yields up to 1,400 pounds per acre have been produced in the Midwest by using six colonies of bees per acre. One or two hives per acre will provide reasonably good pollination.

Crownvetch does not attract bees and requires special techniques to produce a commercial crop of seed. Best yields have been obtained by bringing strong, new hives of bees to the fields every 8 to 10 days. In place of such special provisions, one or more hives of honey bees per acre of crownvetch are of value.

The effects of insect pollination on annual lespedeza, such as Korean, have not been investigated. However, the perennial lespedezas require insect pollination to produce a crop of seed, and honey bees can be used.

Many legumes grown in Illinois for pasture or for purposes other than seed production are visited by honey bees and other bee pollinators. Alfalfa and birdsfoot trefoil as well as alsike, white, and ladino clovers all provide some pollen and nectar and, in turn, are pollinated to varying degrees.

Soybeans are visited by honey bees at Urbana in July and August during their bloom. The beans are a major source of honey in the state. In tests at Urbana, honey bee visits to Clark soybeans did not increase seed yield over that of plants caged to exclude bees. Other studies showed, however, that honey bees can cross-pollinate some soybean varieties. Yields of Corsoy and Hark varieties were increased 14 percent and 16 percent, respectively, by honey bee visits in recent experiments in Wisconsin. Honey bees had no effect on yields of Chippewa 64 in the same study. It seems likely that other varieties also are benefited by visits of honey bees to their blossoms.

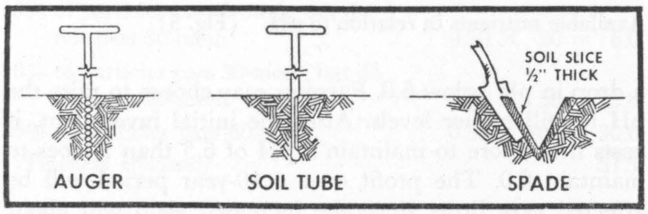
SOIL TESTING AND FERTILITY

Soil Testing

Soil testing is the most important single guide to the profitable application of fertilizer and lime. When soil test results are combined with information about the nutrients that are available to the various crops from the soil profile, the farmer has a reliable basis for planning his fertility program on each field.

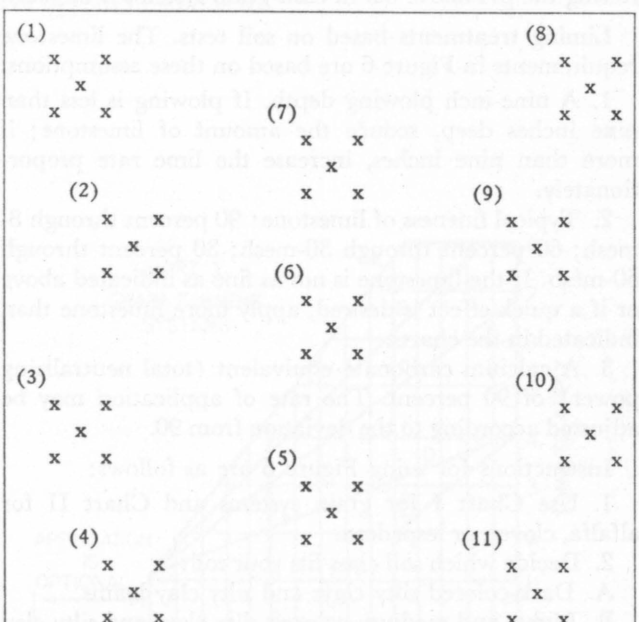
Traditionally, soil testing has been used to decide how much lime and fertilizer to apply. Today, with increased emphasis on the environment, soil tests are also a logical tool to determine areas where adequate or excessive fertilization has taken place. It is just as important to determine where fertilizers should not be used.

How to sample. A soil tube is the best implement to use for taking soil samples, but a spade or auger also can be used (Fig. 3). One composite sample from every 3 to 4 acres is suggested. Five soil cores taken with a tube will give a satisfactory composite sample of approximately 1 to 2 cups in size. You may follow a regular pattern as indicated in Figure 4.



How to take soil samples with an auger, soil tube, and spade. (Fig. 3)

40-acre field



Soil-sampling patterns for a 40-acre field. For a 20-acre field, eliminate 8 through 11. (Fig. 4)

The most common mistake is to take too few samples to represent the fields adequately. Following shortcuts in sampling may produce unreliable results and lead to higher fertilizer costs or lower returns or both.

When to sample. Sampling every four years is strongly suggested. Late summer and fall are the best seasons to collect soil samples from the field. Potassium test results are most reliable during these times. Sampling frozen soil or within two weeks after the soil is frozen should be avoided.

Where to have soil tested. Illinois has about 65 commercial soil-testing services. If you do not know of any, your county extension adviser or fertilizer dealer can advise you of availability of soil testing in your area.

Information to accompany soil samples. The best fertilizer recommendations made are those that are based both on soil test results and a knowledge of the field conditions that will affect nutrient availability. Since the person making the recommendation does not know the conditions of each field, it is important that you provide adequate information with each sample.

This necessary information includes cropping intention for the next four years; the nature of the soil (clay, silty, or sandy; light or dark colored; level or hilly; erodes; well drained or wet; tiled or not; deep or shallow); fertilizer you have been using (amount and grade); whether the field was limed in the past two years; and yield goals for all proposed crops.

What tests to have made. Illinois soil-testing laboratories are equipped to test soils for pH (soil acidity), P_1 (available phosphorus), and K (potassium). No test for nitrogen has proven successful enough to justify a recommendation by University of Illinois agronomists. The reserve phosphorus soil test (P_2) has been discontinued in most laboratories. Rock phosphate usage has decreased, so the need for the test has diminished.

Soil tests for certain secondary and micronutrients may warrant consideration under particular circumstances. These tests may be useful for:

1. *Trouble shooting.* Diagnosing symptoms of abnormal growth. Paired samples representing areas of good and poor growth are needed for analyses.

2. *"Hidden-hunger checkup."* Identifying deficiencies before symptoms appear. However, soil tests are of little value in indicating marginal levels of secondary and micronutrients when crop growth is apparently normal. For this purpose, plant analysis may yield more useful information.

Tests may be made for most of the secondary and micronutrients, but their interpretation is less reliable than interpretation of tests for lime, phosphorus, or potassium. Complete field history and soil information are especially important in interpreting the results of tests for micronutrients.

Lime

A growing amount of Illinois farmland is being shortchanged of lime. One of the most serious limitations in crop production is soil acidity. The use of nitrogen fertilizer has increased rapidly, but the tonnage of limestone used has not kept pace. In Illinois, limestone usage ranged from 4.7 to 4.9 million tons from 1963 to 1966, but it declined to 3.7 to 4.1 million tons in 1971 and 1972. The use of nitrogen fertilizer increased from 175,000 tons in 1963 to 596,000 tons in 1972. It requires about 4 pounds of lime to neutralize the acidity resulting from 1 pound of nitrogen applied as ammonia or urea and as much as 9 pounds of lime to neutralize the acidity resulting from 1 pound of nitrogen as ammonium sulfate. A soil test every four years is the best way to keep check on soil acidity levels.

The effect of soil acidity on plant growth. There are several ways soil acidity affects plant growth. Whenever soil pH is low (i.e., acidity is high), several situations may exist.

1. The concentration of soluble metals may be toxic. Excess solubility of aluminum and manganese has been established experimentally.

2. Populations and activities of the organisms responsible for transformations involving nitrogen, sulfur, and phosphorus may be altered.

3. Calcium may be deficient. This usually occurs when the cation-exchange capacity of the soil is extremely low.

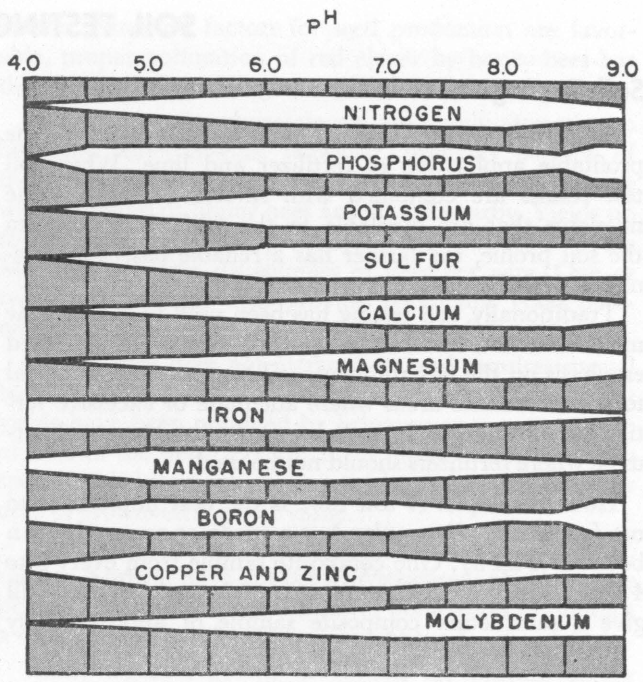
4. Symbiotic nitrogen fixation is impaired greatly on acid soils. The symbiotic relationship requires a narrower range of soil reaction than is necessary for growth of plants not relying on N fixation.

5. Acidic soils are poorly aggregated and have poor tilth. This is particularly true for soils low in organic matter.

6. Availability of mineral elements to plants may be improved. Figure 5 shows the relationship between soil pH and nutrient availability. The wider the white bar, the greater the nutrient availability. For example, phosphorus availability is greatest in the pH range between 6.5 and 7.5, dropping off rapidly below 6.0. Molybdenum availability is increased greatly as soil acidity is decreased. Molybdenum deficiencies usually can be corrected by liming.

Suggested pH goals. For cropping systems with alfalfa and clover, aim for a pH of 6.5 or above unless the soils are pH 6.2 or above without ever having been limed. In those soils, neutral soil is just below plow depth and it probably will not be necessary to apply limestone.

For cash-grain systems (no alfalfa or clover), maintaining a pH of at least 6.0 is a realistic goal. If the soil test shows that the pH is 6.0, apply limestone to prevent



Available nutrients in relation to pH. (Fig. 5)

a drop in pH below 6.0. Farmers may choose to raise the pH to still higher levels. After the initial investment, it costs little more to maintain a pH of 6.5 than it does to maintain 6.0. The profit over a 10-year period will be affected very little, since the increased yield will about offset the original cost of the extra limestone (2 or 3 tons per acre) plus interest.

Research indicates that a profitable yield response from raising the pH above 6.5 in cash-grain systems is unlikely.

Liming treatments based on soil tests. The limestone requirements in Figure 6 are based on these assumptions:

1. A nine-inch plowing depth. If plowing is less than nine inches deep, reduce the amount of limestone; if more than nine inches, increase the lime rate proportionately.

2. Typical fineness of limestone: 90 percent through 8-mesh; 60 percent through 30-mesh; 30 percent through 60-mesh. If the limestone is not as fine as indicated above or if a quick effect is desired, apply more limestone than indicated in the charts.

3. A calcium carbonate equivalent (total neutralizing power) of 90 percent. The rate of application may be adjusted according to the deviation from 90.

Instructions for using Figure 6 are as follows:

1. Use Chart I for grain systems and Chart II for alfalfa, clover, or lespedeza.

2. Decide which soil class fits your soil:

A. Dark-colored silty clays and silty clay loams.

B. Light- and medium-colored silty clays and silty clay loams; dark-colored silt and clay loams.

C. Light- and medium-colored silt and clay loams; dark- and medium-colored loams; dark-colored sandy loams.

D. Light-colored loams; light- and medium-colored sandy loams; sands.
E. Muck and peat.

Color is related to organic matter. Light-colored soils usually have less than 2.5 percent organic matter; medium-colored soils have 2.5 to 4.5 percent organic matter; dark-colored soils have above 4.5 percent organic matter; sands are excluded.

The "typical" limestone on which Figure 6 is based has an effective neutralizing value (ENV) of 46.35. Here are the steps to follow (using the fineness and neutralizing power values) to calculate the ENV of your limestone.

First, determine what percentages of the limestone particles fall into four size groups. Then, multiply these four percentages by the efficiency factors (E.F.) listed in Table 34 to obtain the size fraction efficiency. Total the size fraction efficiencies to obtain the fineness efficiency as illustrated below.

	% × E.F. = Size fraction efficiency
10% of lime particles do not pass 8-mesh	0.10 × 5 = 0.5
30% of particles pass 8-mesh, but do not pass 30-mesh	0.30 × 20 = 6.0
30% of particles pass 30-mesh, but do not pass 60-mesh	0.30 × 50 = 15.0
30% of particles pass 60-mesh	0.30 × 100 = 30.0
Fineness efficiency	51.5

Then, the effective neutralizing value will equal the fineness efficiency multiplied by the calcium carbonate equivalent (46.35 = 51.5 × 90 percent). Your limestone dealer can tell you what the calcium carbonate equivalent of your limestone is.

Table 34. — Comparative Value of Limestone Particle Sizes

Size fraction	Efficiency factor
Through 60-mesh	100
30- to 60-mesh	50
8- to 30-mesh	20
Over 8-mesh	5

Limestone quality. You should buy limestone on the basis of quality, and premium limestone should sell for a premium price.

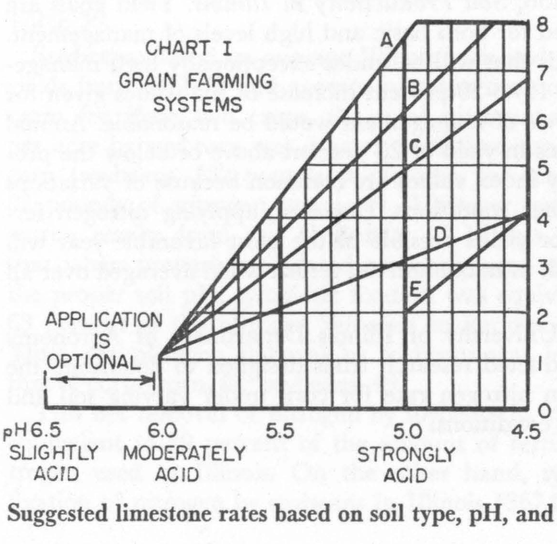
Limestone quality is measured by fineness and neutralizing power. The value of lime in correcting soil acidity problems can be calculated easily using the efficiency factors in Table 34.

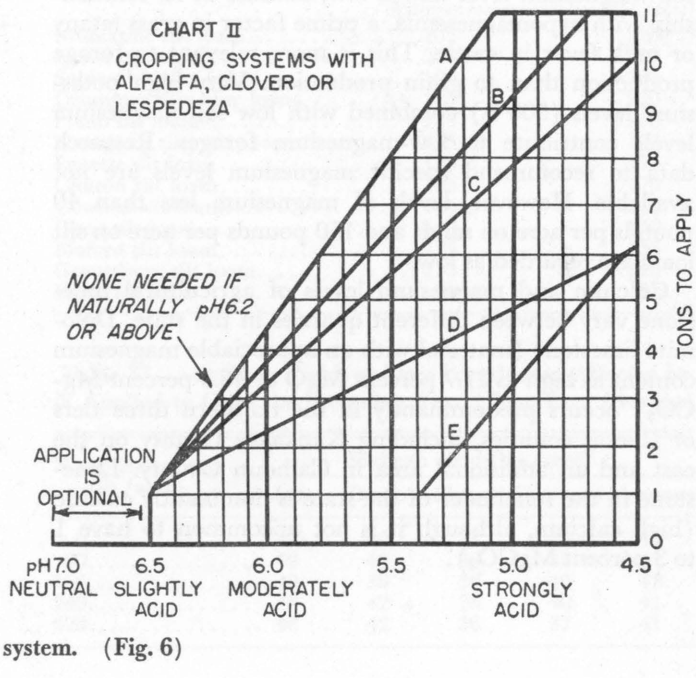
To compare different limestones to the typical limestone on which Figure 6 is based, follow this procedure:

1. Calculate the ENV for your limestone as explained above.
2. Divide 46.35 (the ENV for typical limestone) by the calculated ENV value for your limestone.

ENV greater than that of typical limestone. If the fineness efficiency value of your limestone is 49.5 to 53.5, you may reduce the amount of lime to use by 1 percent for each 1 percent of calcium carbonate equivalent above 90 percent.

If the ENV of your limestone is greater than 46.35 and the calcium carbonate equivalent is 88 to 92 percent, then the increase in ENV is because of the fineness of the grind, and no adjustment in the amount of lime used per acre is justified. However, the finer materials will react more rapidly to neutralize acid soils than the typical limestone, and this may be of benefit in some situations.





Suggested limestone rates based on soil type, pH, and cropping system. (Fig. 6)

ENV less than that of typical limestone. If your limestone has an ENV less than 46.35, then you should increase the amount to apply per acre. Multiply the amount of limestone needed per acre on your land by the value you calculated in step 2 above (for instance, 2 tons per acre multiplied by a value of 1.1 would equal about 2.2 tons to apply per acre).

If high initial cost is not a deterrent, you may apply the entire amount at one time. If cost is a factor and the amount of limestone needed is 6 tons or more per acre, apply it in split applications of about two-thirds the first time and the remainder three or four years later.

Lime incorporation. Lime does not react with acid soil very far from the particle. However, special tillage operations to mix lime with soil usually are not necessary; this has been true with conventional tillage that included use of the moldboard plow. Systems of tillage that use a chisel plow or field cultivator rather than a moldboard plow may necessitate a reexamination of soil acidity within the root zone.

Calcium-Magnesium Balance in Illinois Soils

Soils in northern Illinois usually contain more magnesium than those in central and southern sections because of the high magnesium content in the rock from which the soils developed and because northern soils are geologically younger. This has caused some to wonder whether the magnesium level is too high. There have been reports of suggestions that either gypsum or low-magnesium limestone from southern Illinois quarries should be applied. However, no one operating a soil-testing laboratory or selling fertilizer in Illinois has put forth research to justify concern over too narrow a calcium:magnesium ratio.

On the other hand, there is justifiable concern over a soil magnesium level that is low, because of its relationship with hypomagnesemia, a prime factor in grass tetany or milk fever in cattle. This is more relevant to forage production than to grain production. Very high potassium levels (500+) combined with low soil magnesium levels contribute to low-magnesium forages. Research data to recommend specific magnesium levels are not available. However, levels of magnesium less than 40 pounds per acre on sands and 150 pounds per acre on silt loam are regarded as low.

Calcium and magnesium levels of agricultural limestone vary between different quarries in the state. Dolomite limestone (material with an appreciable magnesium content as high as 21.7 percent MgO or 46.5 percent $MgCO_3$) occurs predominantly in the northern three tiers of Illinois counties, including Kankakee County on the east and an additional area in Calhoun County. Limestone in the remainder of the state is dominantly calcitic (high calcium, although it is not uncommon to have 1 to 3 percent $MgCO_3$).

For farmers following a grain system of farming, there are no agronomic reasons to recommend either that farmers in northern Illinois bypass local sources, which are medium to high in magnesium, and pay a premium for low-magnesium limestone from southern Illinois or that farmers in southern Illinois order limestone from northern Illinois quarries because of magnesium content.

For farmers with a livestock program or who produce forages in the claypan and fragipan regions of the south where soil magnesium levels may be marginal, it is appropriate to use a soil test to verify the conditions and to use dolomite limestone or supplemental magnesium fertilization.

Nitrogen

Harvested crops remove more nitrogen than any other nutrient from Illinois soils. Erosion reduces the nitrogen content of soils because the surface soil is richest in nitrogen and erodes first. Further nitrogen losses occur as a result of denitrification and leaching. About 40 percent of the original nitrogen and organic matter content has been lost from typical Illinois soils since farming began.

The use of nitrogen fertilizer is necessary if Illinois agriculture is to continue to provide adequate crop production to aid in meeting the ever-increasing world demand for food. With the world shortage of nitrogen fertilizer and energy, all nitrogen fertilizers should be used in the most efficient manner possible. Factors that influence efficiency of fertilizer use are discussed in the following sections.

Rate of Application

Corn. Yield goal is one of the major considerations to use in determining the optimum rate of nitrogen application for corn. These goals should be established for each field, taking into account the soil type and management level under which the crop will grow.

For Illinois soils, suggested productivity index values are given in Illinois Cooperative Extension Service Circular 1156, *Soil Productivity in Illinois.* Yield goals are presented for both basic and high levels of management. For fields that will be under exceptionally high management, a 15-to-20-percent increase of the values given for high levels of management would be reasonable. Annual variations in yield of 20 percent above or below the productivity index values are common because of variations in weather conditions. However, applying nitrogen fertilizer for yields possible in the most favorable year will not result in maximum net return when averaged over all years.

The University of Illinois Department of Agronomy has conducted research trials designed to determine the optimum nitrogen rate for corn under varying soil and climatic conditions.

Table 35. — Economic Optimum Nitrogen Rate Experimentally Determined for Eight Locations as Affected by Corn-Nitrogen Price Ratios

Location and rotation	Corn-nitrogen price ratio 10:1 Optimum yield (bu./acre)	10:1 Optimum N rate (lb./bu.)	20:1 Optimum yield (bu./acre)	20:1 Optimum N rate (lb./bu.)
Brownstown (continuous corn)	83	1.30	86	1.47
Carthage (continuous corn)	144	1.22	147	1.29
DeKalb (continuous corn)	141	1.28	143	1.31
Urbana (continuous corn)	171	1.17	173	1.24
Average of continuous corn		1.24		1.33
Dixon (corn-soybeans)	131	1.37	134	1.58
Hartsburg (corn-soybeans)	156	1.19	157	1.27
Oblong (corn-soybeans)	123	1.11	126	1.23
Toledo (corn-soybeans)	123	1.12	124	1.20
Average of corn-soybeans		1.20		1.32
Average of all locations		1.22		1.32

The results of these experiments show that average economic optimum nitrogen rates varied from 1.22 to 1.32 pounds of nitrogen per bushel of corn produced when nitrogen was spring applied (Table 35). The lower rate of application (1.22 pounds) would be recommended at a corn-nitrogen price ratio (corn price per bushel to nitrogen price per pound) of 10:1 and the higher rate (1.32 pounds) at a price ratio of 20:1.

As would be expected, the nitrogen requirement was lower at those sites having a corn-soybean rotation than at sites with continuous corn because of the nitrogen contribution from soybeans (see nitrogen rate adjustment section).

With the exception of Dixon, which was based on limited data, Brownstown and DeKalb had the highest nitrogen requirement per bushel of corn produced. This higher requirement may be in part the result of the higher denitrification losses that frequently have been observed at Brownstown and DeKalb.

Based on these results, examples of the recommended rate of nitrogen application for selected Illinois soils under a high level of management are indicated in Table 36.

Soybeans. Based on average Illinois corn and soybean yields from 1971-73 and average nitrogen content of the grain for these two crops, the total nitrogen removed per acre by soybeans was greater than that removed by corn (soybeans, 132 pounds of nitrogen per acre; corn, 82 pounds of nitrogen per acre). However, recent research results from the University of Illinois indicate that when properly nodulated soybeans were grown at the proper soil pH, symbiotic fixation was equivalent to 63 percent of the nitrogen removed in harvested grain. Thus, net nitrogen removal by soybeans was less than that of corn (corn, 82; soybeans, 49).

This net removal of nitrogen by soybeans in 1973 was equivalent to 39 percent of the amount of fertilizer nitrogen used in Illinois. On the other hand, symbiotic fixation of nitrogen by soybeans in Illinois (367,000 tons of N) was equivalent to 67 percent of the fertilizer nitrogen used in Illinois.

Even though there is a rather large net nitrogen removal from soil by soybeans (49 pounds of nitrogen per acre), research at the University of Illinois has not generally indicated any soybean yield increase caused by either residual nitrogen remaining in the soil or nitrogen applied for the soybean crop.

A. Residual from nitrogen applied to corn (Table 37). Soybean yields at four locations were not increased by

Table 36. — Nitrogen Recommendations for Selected Illinois Soils Under High Level of Management

Soil type	Corn-nitrogen price ratio 10:1	20:1
	Nitrogen recommendation (lbs./acre)	
Muscatine silt loam	205	220
Ipava silt loam	200	215
Sable silty clay loam	190	205
Drummer silty clay loam	185	200
Plano silt loam	185	200
Hartsburg silty clay loam	175	190
Fayette silt loam	155	170
Clinton silt loam	155	170
Cowden silt loam	145	160
Cisne silt loam	140	150
Bluford silt loam	125	135
Grantsburg silt loam	115	125
Huey silt loam	80	85

Table 37. — Soybean Yields at Four Locations as Affected by N Applied to Corn the Preceding Year (Four-Year Average)

N applied to corn (lb./acre)	Soybean yield (bu./acre) Aledo	Dixon	Elwood	Kewanee	Average
0	48	40	37	40	41
80	49	40	36	38	41
160	48	39	36	40	41
240	48	42	36	40	41
320	48	42	36	37	41

residual nitrogen remaining in the soil even when nitrogen rates as high as 320 pounds per acre had been applied to corn the previous year.

B. Nitrogen on continuous soybeans (Table 38). After 18 years of continuous soybeans at Hartsburg, yields were unaffected by nitrogen rates.

C. High rates of added nitrogen (Table 39). In 1968 a study was started at Urbana using moderate rates of nitrogen. Rates were increased in 1969 so that the high rates could furnish more than the total nitrogen needs of soybeans. Yields were not affected by nitrogen in 1968, but a tendency toward a yield increase occurred in 1969 and 1970 with 400 pounds per acre of nitrogen. However, this rate of nitrogen would not be economical at current prices.

Wheat, oats, and barley. The rate of nitrogen application to be used on wheat, oats, and barley is dependent on soil type, variety to be grown, and future cropping intentions (Table 40). Light-colored (low organic matter) soils require the highest rate of nitrogen application as they have a low capacity to supply nitrogen. Deep, dark-colored soils require relatively low rates of nitrogen application for maximum yields. Estimates of organic matter content for soils of Illinois can be obtained from Agronomy Fact Sheet SP-36, "Average Organic Matter Content in Illinois Soil Types," or by using University of Illinois publication AG-1941, "Color Chart for Estimating Organic Matter in Mineral Soils."

Higher rates of application can be used on the stiff-strawed wheat varieties such as Abe, Arthur, Arthur 71, Blueboy, Blueboy II, and Oasis than on the other varieties, which are more susceptible to lodging. Nearly all recommended oat varieties grown in Illinois have good straw strength; thus, higher nitrogen rates are recommended. Most varieties of barley grown in Illinois are weak strawed and, thus, susceptible to lodging.

Some wheat in Illinois serves as a companion crop for legume or legume-grass seedings. On those fields, it is best to apply nitrogen fertilizer at slightly below the optimum rate, as unusually heavy vegetative growth of wheat competes unfavorably with the young forage seedlings (Table 40).

Nitrogen fertilizer efficiency normally will be at a maximum if no nitrogen is fall applied to the dark-colored soils and only a small amount (15 to 20 pounds per acre) is drill applied at planting time on the light colored soils. The remainder of the nitrogen should be topdressed early in the spring of the year.

The amount of nitrogen needed for good fall growth is not large because the total uptake in roots and tops prior to cold weather is not likely to exceed 30 to 40 pounds per acre. If all of the recommended nitrogen were fall applied, excessive vegetative growth could occur in the fall and increase the probability of disease occurrence.

Table 38. — Yield of Continuous Soybeans With Rates of Added N at Hartsburg

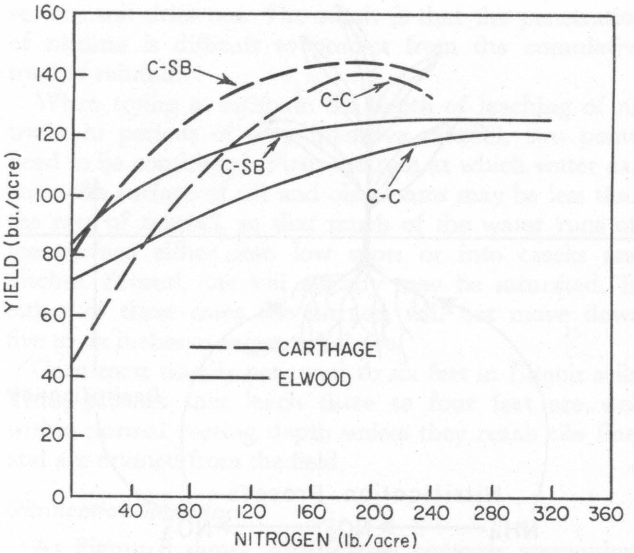
N (lb./acre/year)	Soybean yield (bu./acre) 1968-71	1954-71
0	43	37
40	42	36
120	43	37

Table 39. — Soybean Yields as Affected by High Rates of Nitrogen

Nitrogen (lb./acre)			Soybean yield (bu./acre)		
1968	1969	1970	1968	1969	1970
0	0	0	54	53	40
40	200	200	54	57	41
80	400	400	56	57	45
120	800	800	53	55	42
160	1,600	1,600	55	34	36

Table 40. — Recommended Nitrogen Application Rates for Wheat, Oats, and Barley

Soil situation	Organic matter content	Fields with alfalfa or clover seeding: Stiff-strawed varieties	Fields with alfalfa or clover seeding: Other adapted wheat and oat varieties and all varieties of barley	Fields with no alfalfa or clover seeding: Stiff-strawed varieties	Fields with no alfalfa or clover seeding: Other adapted wheat and oat varieties and all varieties of barley
		Nitrogen (lb./acre)			
Soils low in capacity to supply nitrogen: inherently low in organic matter (forested soils)	<2%	50–70	40–60	70–90	50–70
Soils medium in capacity to supply nitrogen: moderately dark-colored soils	2–3%	30–50	20–40	50–70	30–50
Soils high in capacity to supply nitrogen: all deep, dark-colored soils	>3%	20–30	0	40–50	20–30



Effect of crop rotation and applied nitrogen on corn yield. (Fig. 7)

Hay and pasture grasses. The species grown, period of use, and yield goal determine optimum nitrogen fertilization (Table 41). The lower rate of application is recommended on those fields where an inadequate stand or moisture limits production.

Kentucky bluegrass is shallow rooted and susceptible to drouth. Consequently, the most efficient use of nitrogen by bluegrass is from an early spring application. September applications are second choice. September fertilization stimulates both fall and early spring growth.

Orchardgrass, smooth bromegrass, tall fescue, and reed canarygrass are more drouth tolerant than bluegrass and can use higher rates of nitrogen more effectively than bluegrass. Because more uniform pasture production is obtained by splitting high rates of nitrogen, two or more applications are suggested.

Make the first nitrogen application in March in southern Illinois, early April in central Illinois, and mid-April in northern Illinois if extra spring growth can be utilized. If spring growth is adequate without extra nitrogen, the first application can be delayed until after the first harvest or grazing cycle to distribute production more uniformly throughout the summer. However, total production likely will be less if nitrogen is applied after first harvest rather than in early spring. The second application of nitrogen usually is made after the first harvest or first grazing cycle. However, this application can be deferred until August or early September to stimulate fall growth.

Legume-grass mixtures should not receive nitrogen if legumes make up 30 percent or more of the mixture. The main objective is to maintain the legume, so emphasis should be on phosphorus and potassium rather than on nitrogen.

After the legume has declined to less than 30 percent of the mixture, the object of fertilizing is to increase the yield of grass. The suggested rate of nitrogen is about 50 pounds per acre when legumes make up 20 to 30 percent of the mixture and 100 pounds or more when legumes are less than 20 percent of the mixture.

Table 41. — Nitrogen Fertilization of Hay and Pasture Grasses

Species	Time of application: Early spring	After first harvest	After second harvest	Early September
	Nitrogen (lb./acre)			
Kentucky bluegrass	60–80			(see text)
Orchardgrass	75–125	75–125		
Smooth bromegrass	75–125	75–125		50[a]
Reed canarygrass	75–125	75–125		50[a]
Tall fescue for winter use		100–125	100–125	50[a]

[a] Optional if extra fall growth is needed.

Table 42. — Adjustments in Nitrogen Recommendations

Crop to be grown	Factors resulting in reduced nitrogen requirement: After soybeans	1st year after alfalfa or clover (Plants/sq.ft.): 5	2-4	<2	2nd year after alfalfa or clover (Plants/sq. ft.): 5	<5	Manure
	Nitrogen reduction (lb./acre)						
Corn	40	100	50	0	30	0	5[a]
Wheat	10	30	10	0	0	0	5[a]

[a] Nitrogen contribution in pounds per ton of manure.

Rate Adjustments

In addition to determining nitrogen rates, consideration should be given to other agronomic factors that influence available nitrogen. These adjustments include past cropping history and the use of manure (Table 42), as well as date of planting.

Experiments conducted at the Carthage experimental field comparing nitrogen requirements of continuous corn and corn following soybeans indicate a soil nitrogen contribution of 30 to 40 pounds per acre at the lower rates of applied nitrogen and 20 to 30 pounds per acre at the higher rates of nitrogen application (Fig. 7). At Elwood, the yield differential between continuous corn and corn-soybeans continues to widen at higher rates of nitrogen application. It is doubtful that this yield differential is entirely the result of nitrogen contributions from the soybeans. The contribution of legumes, either soybeans or alfalfa, to wheat will be less than the contribution to corn because the oxidation of the organic nitrogen from these legumes will not be as rapid in early spring, when the nitrogen needs of small grain are greatest, as it is in the summer, when nitrogen needs of corn are greatest.

Manure generally is considered to contain 10 pounds of nitrogen, 5 pounds of phosphorus (P_2O_5), and 10 pounds of potassium (K_2O) per ton. However, there is some variation in content dependent on source and method of handling (Table 43). Regardless of source, however, only 50 percent of the total nitrogen will be available to the crop during the first year after application.

Research at the Northern Illinois Research Center for several years showed that as planting was delayed, less nitrogen fertilizer was required for most profitable yield. Based upon that research, Illinois agronomists suggest that for each week of delay in planting after the optimum date for the area, the nitrogen rate can be reduced 20 pounds per acre down to 80 to 90 pounds per acre as the minimum for very late planting in a corn-soybean cropping system. Suggested reference dates are April 10 to 15 in southern Illinois, April 20 to May 1 in central Illinois, and May 1 to 10 in northern Illinois. This adjustment is, of course, possible only if the nitrogen is sidedressed.

Because of the importance of the planting date, farmers are encouraged not to delay planting just to apply nitrogen fertilizer: plant, then sidedress.

Reactions in the Soil

Efficient use of nitrogen fertilizer requires an understanding of how nitrogen behaves in the soil. Key points to consider are the change from ammonium (NH_4^+) to nitrate (NO_3^-) and movements and transformations of nitrate.

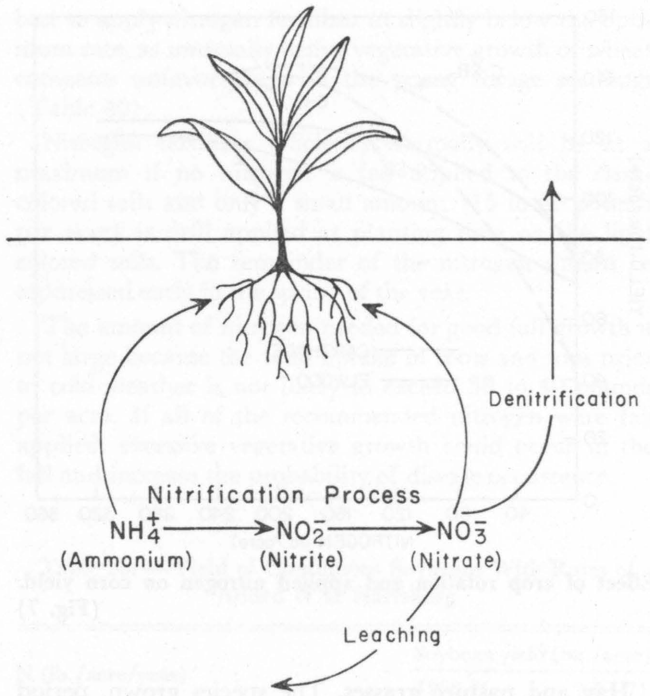
A high percentage of the nitrogen applied in Illinois is in the ammonium form or converts to ammonium (anhydrous ammonia and urea, for example) soon after application. Ammonium nitrogen is held by the soil clay and organic matter and cannot move very far until it nitrifies (changes from ammonium to nitrate). In the nitrate form, nitrogen can be lost by either denitrification or leaching (Fig. 8).

Denitrification. Denitrification is believed to be the main process by which nitrate and nitrite nitrogen are lost, except on sandy soils, where leaching is more important. Denitrification involves only nitrogen in the form of either nitrate (NO_3^-) or nitrite (NO_2^-).

The amount of denitrification depends mainly on (1) how long water stands on the soil surface or how long the surface is saturated; (2) the temperature of the soil and water; (3) the pH of the soil; and (4) the amount of energy material available to denitrifying organisms.

When water stands on the soil or when the surface is completely saturated in fall or early spring, nitrogen loss is likely to be small because (a) much nitrogen is still in the ammonium rather than nitrate form, and (b) the soil is cool and denitrifying organisms are not very active.

Many fields in east central Illinois and to a lesser extent in other areas have low spots where surface water collects at some time during the spring or summer. The flat clay-pan soils also are likely to be saturated, though not flooded. Sidedressing would avoid the risk of spring loss on these soils, but would not affect midseason loss. Unfortunately, these are the soils on which sidedressing is difficult in wet years.



Nitrogen reactions in the soil. (Fig. 8)

Table 43. — Average Composition of Manure

Kind of animal	Nutrients (lb./ton) Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
Dairy cattle	11	5	11
Beef cattle	14	9	11
Hogs	10	7	8
Chicken	20	16	8
Dairy cattle (liquid)	5(26)[a]	2(11)	4(23)
Beef cattle (liquid)	4(21)	1(7)	3(18)
Hogs (liquid)	10(56)	5(30)	4(22)
Chicken (liquid)	13(74)	12(68)	5(27)

[a] **Parenthetical numbers are pounds of nutrients per 1,000 gallons.**

Denitrification is difficult to measure in the field, but several laboratory studies show that it can happen very quickly. At temperatures that are common in midsummer, most nitrate nitrogen can be denitrified within three to five days at pH 6.0 or above.

Leaching. In silt loams and clay loams, one inch of rainfall moves down about five to six inches, though some of the water moves farther in large pores through the profile and carries nitrates with it.

In sandy soils, each inch of rainfall moves nitrates down about one foot. If the total rainfall at one time is more than six inches, little nitrate will be left within rooting depth on sands.

Between rains, there is some upward movement of nitrates in moisture that moves toward the surface as the surface soil dries out. The result is that the penetration of nitrates is difficult to predict from the cumulative total of rainfall.

When trying to estimate the depth of leaching of nitrates in periods of very intensive rainfall, two points need to be considered. First, the rate at which water can enter the surface of silt and clay loams may be less than the rate of rainfall, so that much of the water runs off the surface either into low spots or into creeks and ditches. Second, the soil already may be saturated. In either of these cases the nitrates will not move down five to six inches as suggested above.

Corn roots usually penetrate to six feet in Illinois soils. Thus, nitrates that leach three to four feet are well within normal rooting depth unless they reach tile lines and are drained from the field.

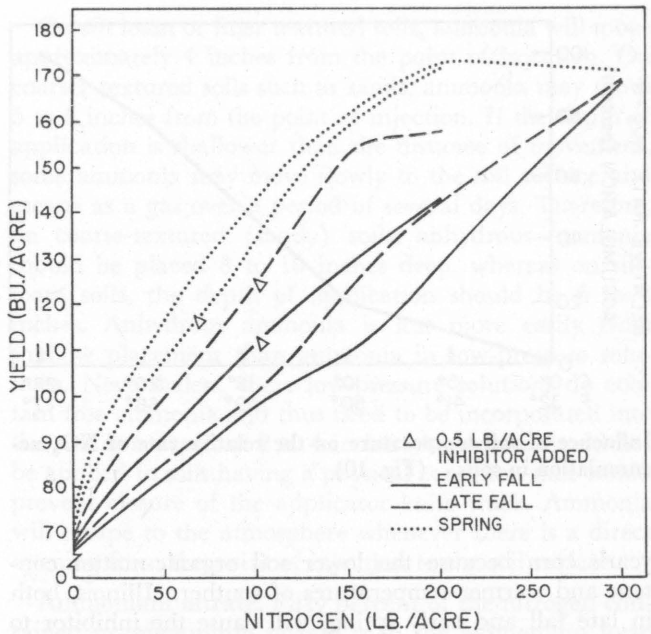
Nitrification Inhibitors

As Figure 8 shows, nitrification converts ammonium nitrogen into the nitrate form of nitrogen and so increases the potential for soil nitrogen loss. This conversion process can be retarded by using nitrification inhibitors. When inhibitors were properly applied in one experiment, as much as 42 percent of soil-applied ammonia remained in the ammonium form through the early part of the growing season, in contrast to the 4 percent that remained when inhibitors were not used. Inhibitors can therefore have a significant effect on crop yields. However, the success of application will vary with the soil condition, time of year, type of soil, geographic location, rate of nitrogen application, and weather conditions that occur after the nitrogen is applied and before it is absorbed by the crop.

Considerable research throughout the Midwest has shown that inhibitors significantly increase yields only under wet soil conditions. When inhibitors were applied in years of excessive rainfall, corn yield increases ranged from 10 to 30 bushels per acre; when moisture conditions were not as conducive to denitrification or leaching, inhibitors produced no increase.

For the first four years of one experiment conducted by the University of Illinois, nitrification inhibitors produced no effect on grain yields because soil moisture levels were not significantly high. In early May of the fifth year, however, when soils were saturated with water for a long time, the application of an inhibitor in the preceding fall significantly increased corn yields (Fig. 9). Furthermore, at a nitrogen application rate of 150 pounds per acre, the addition of an inhibitor increased grain yields more than the addition of another 40 pounds of nitrogen (Fig. 9). Under the conditions of that experiment, therefore, it was more economical to use an inhibitor than to apply more nitrogen.

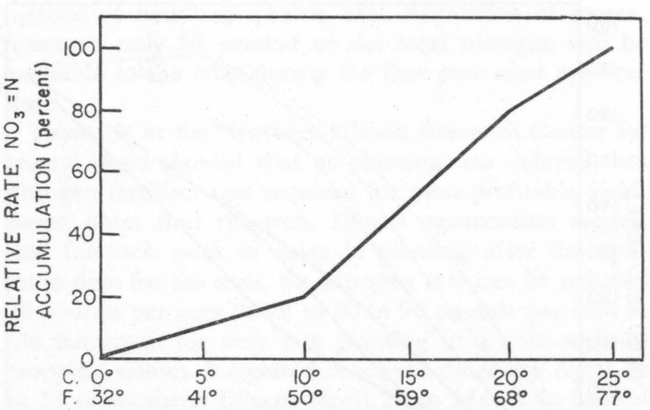
A nitrification inhibitor probably would not be effective with sidedressed nitrogen because soils do not normally remain saturated with water for very long during the growing season after a sidedressing operation. Moreover, the short time between application and absorption by the crop greatly reduces the potential for nitrogen loss.



Effect of nitrification inhibitors on corn yields at varying nitrogen application rates. (Fig. 9)

The longer the period between nitrogen application and absorption by the crop, the greater the probability that nitrification inhibitors will contribute to higher yields. However, the length of time that fall-applied inhibitors will remain in the soil is partly dependent on soil temperature. On one plot, a Drummer soil that had received an inhibitor application when soil temperatures were 55° F. retained nearly 50 percent of the applied ammonia in ammonium form for approximately 5 months. When soil temperatures were at 70° F., it retained the same amount of ammonia for only 2 months. Fall application of nitrogen with inhibitors should therefore be delayed until soil temperatures reach 60° F. or less, and even though temperatures may decrease to 60° F. in early September, it is advisable to delay applications until the last week in September in northern Illinois and the first week of October in central Illinois.

In general, poorly or imperfectly drained soils will probably benefit the most from nitrification inhibitors. Moderately well drained soils that undergo frequent periods of three or more days of flooding in the spring would also benefit, and coarse-textured soils (sands) are likely to benefit more than finer-textured soils because they have a higher potential for leaching. However, time of application and geographic location must be considered along with soil type. Employing nitrification inhibitors could significantly improve the efficiency of fall-applied nitrogen on the loams, silts, and clays of central and northern Illinois in years when the soil is very wet in the spring. At the same time, presently available inhibitors will not adequately reduce the rate of nitrification in the low organic-matter soils of southern Illinois when nitrogen is applied in the fall for the following



Influence of soil temperature on the relative rate of NO_3 accumulation in soils. (Fig. 10)

year's corn because the lower soil organic-matter content and warmer temperatures of southern Illinois, both in late fall and early spring, will cause the inhibitor to degrade too rapidly. Furthermore, applying an inhibitor on sandy soils in the fall will not adequately reduce nitrogen loss because the potential for leaching is too high. Therefore, fall applications of nitrogen with inhibitors are not recommended for sandy soils or for soils with low organic-matter content, especially for those soils found south of Interstate Highway 70.

In the spring, preplant applications of inhibitors may be beneficial on nearly all types of soil from which nitrogen loss frequently occurs, especially on sandy soils and southern Illinois soils. Again, inhibitors are more likely to have an effect when subsoils are recharged with water than when subsoils are dry at the beginning of spring.

Nitrification inhibitors are most likely to increase yields when nitrogen is applied at or below the optimum rate. When nitrogen is applied at a rate greater than that required for optimum yields, benefits from an inhibitor are unlikely, even when there is excessive moisture in the soil.

Inhibitors should be viewed as soil management tools that can be used to reduce nitrogen loss. It is not safe to assume, however, that the use of a nitrification inhibitor will make it possible to reduce nitrogen rates below those currently recommended, since those rates were developed with the assumption that no significant amount of nitrogen would be lost.

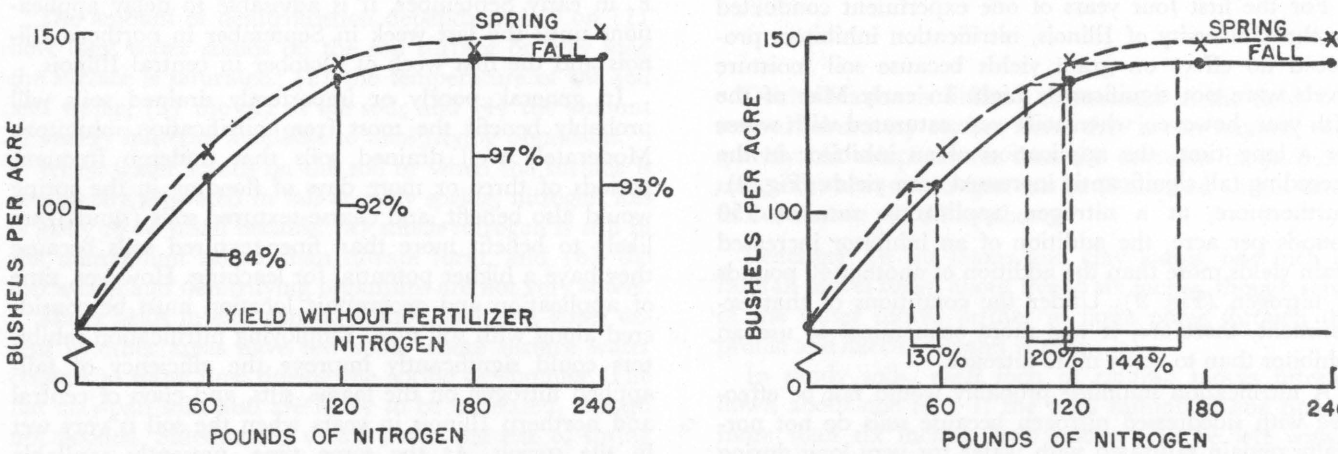
Time of Nitrogen Application

In recent years farmers in central and northern Illinois have been encouraged to apply nitrogen in nonnitrate form in the late fall any time after the soil temperature at four inches was below 50° F., except on sandy, organic, or very poorly drained soils.

The 50° F. level for fall application is believed to be a realistic guideline for farmers. Applying nitrogen earlier involves risking too much loss (Fig. 10). Later application involves risking wet or frozen fields, which would prevent application and fall plowing. Average dates on which these temperatures are reached are not satisfactory guides because of the great variability from year to year. Soil thermometers should be used to guide fall nitrogen applications.

In Illinois most of the nitrogen applied in late fall or very early spring will be converted to nitrate by corn-planting time. Though the rate of nitrification is slow (Fig. 10), the period of time is long during which the soil temperature is between 32° F. and 40° to 45° F.

The results from 18 experiments in central and northern Illinois in four recent years (Fig. 11) show that fall-applied ammonium nitrate (one-half ammonium, one-half nitrate) was less effective than spring-applied nitrogen. There are two ways to compare efficiency. For example, in Figure 11, left, 120 pounds of nitrogen applied in the fall produced 92 percent as much increase as the same amount applied in the spring. But looked



Comparison of fall- and spring-applied ammonium nitrate, 18 experiments in central and northern Illinois, 1966-1969 (DeKalb, Carthage, Carlinville, and Hartsburg). Figure at left shows increased yield from fall fertilizer application as a percent of yield increases achieved when fertilizer was applied in the spring. Figure at right shows amount of fertilizer you need to apply in the fall to obtain a given yield as a percent of the fertilizer needed to obtain that same yield with spring application. (Fig. 11)

at another way, it required 120 pounds of nitrogen to produce as much yield increase in the fall as was produced by 100 pounds in the spring (Fig. 11, right). At higher nitrogen rates, the comparisons become less favorable for fall application because the yield leveled off 6 to 8 bushels below that from spring application.

Unfortunately, no recent results are available to compare fall, spring, and sidedressed applications of a nitrogen source that is entirely in the ammonium form. The effectiveness of fall-applied nitrogen might be greater if an all-ammonium form is used. The failure of the highest rate to offset the lower efficiency from fall-applied ammonium nitrate remains an important mystery. Five-year comparisons of spring and sidedressed nitrogen at DeKalb in northern Illinois show that spring and sidedressed applications were equal. In dry years, spring application was better. In wet years, sidedressing was better.

In consideration of the date at which nitrates are formed and the conditions that prevail thereafter, the difference in susceptibility to denitrification and leaching loss between late-fall and early-spring applications of ammonium sources is probably small. Both are, however, more susceptible to loss than is nitrogen applied at planting time or as a sidedressing.

Anhydrous ammonia nitrifies more slowly than other ammonium forms and, therefore, is slightly preferred for fall applications. It is well suited to early spring application, provided the soil is dry enough for good dispersion of ammonia and closure of the applicator slit.

Aerial application. Recent research at the University of Illinois has indicated that an aerial application of dry urea will result in increased yield. This practice should not be considered as a replacement for normal nitrogen application, but rather as an emergency treatment in instances where corn is too tall for normal applicator equipment. Aerial application of nitrogen solutions on growing corn is not recommended, as extensive leaf damage will likely result if the rate of application is greater than 10 pounds of nitrogen per acre.

Which Nitrogen Fertilizer?

The bulk of the nitrogen fertilizer materials available for use in Illinois provides nitrogen in the combined form of ammonia, ammonium, urea, and nitrate. For many uses on a wide variety of soils, all forms are likely to produce about the same yield provided that they are properly applied.

Ammonia. Nitrogen materials that contain free ammonia (NH_3), such as anhydrous ammonia or low-pressure solutions, must be injected into the soil in order to avoid gaseous loss of ammonia. Upon injection into the soil, ammonia quickly reacts with water to form ammonium (NH_4^+). In this positively charged form, the ion is not susceptible to gaseous loss because it is temporarily attached to the negative charges on clay and organic matter. Some of the ammonia reacts with organic matter to become a part of the soil humus.

On silt loam or finer textured soils, ammonia will move approximately 4 inches from the point of injection. On coarser textured soils such as sands, ammonia may move 5 to 6 inches from the point of injection. If the depth of application is shallower than the distance of movement, some ammonia may move slowly to the soil surface and escape as a gas over a period of several days. Therefore, on coarse-textured (sandy) soils, anhydrous ammonia should be placed 8 to 10 inches deep, whereas on silt-loam soils, the depth of application should be 6 to 8 inches. Anhydrous ammonia is lost more easily from shallow placement than ammonia in low-pressure solutions. Nevertheless, these low-pressure solutions do contain free ammonia and thus need to be incorporated into the soil at a depth of 2 to 4 inches. Ammonia should not be applied to soils having a physical condition that would prevent closure of the applicator knife track. Ammonia will escape to the atmosphere whenever there is a direct opening from the point of injection to the soil surface.

Ammonium nitrate. Fifty percent of the nitrogen contained in ammonium nitrate is in the ammonium form and 50 percent is in the nitrate form. That present as ammonium attaches to the negative charges on the clay and organic matter particles and remains in that state until it is utilized by the plant or converted to the nitrate ions by microorganisms present in the soil. Since 50 percent of the nitrogen is present in the nitrate form, this product is more susceptible to loss from leaching and denitrification. Thus, ammonium nitrate should not be applied to sandy soils because of the likelihood of leaching, nor should it be applied far in advance of the time the crop needs the nitrogen because of the possibility of loss by denitrification.

Urea. The chemical formula for urea is $CO(NH_2)_2$. In this form, it is very soluble and moves freely up and down with soil moisture. After being applied to the soil, urea is converted to ammonia either chemically or by the enzyme urease. The speed with which this conversion occurs depends largely on temperature. At low temperatures conversion is slow, but at temperatures of 55° F. or higher conversion is rapid.

If the conversion of urea occurs on the soil surface or on the surface of crop residue or leaves, some of the resulting ammonia will be lost as a gas to the atmosphere. The potential for loss is greatest when:

1. Temperatures are greater than 55° F. Loss is less likely with winter or early spring applications.
2. Considerable crop residue remains on the soil surface.
3. Application rates are greater than 100 lbs. N per acre.
4. The soil surface is moist and rapidly drying.
5. Soils have a low cation-exchange capacity.
6. Soils are neutral or alkaline in reaction.

Research conducted at both the Brownstown and Dixon Springs Research Centers have shown that surface

Table 44. — Effect of Source of Nitrogen for Zero-Till Corn

Source	Nitrogen: Date of application	Nitrogen: Method of application	Nitrogen: Rate lbs./acre	Brownstown 1974-77 avg.	Dixon Springs 1974	Dixon Springs 1975
				Yield (bu./acre)		
Control....	..	..	0	52	50	
Ammonium nitrate....	early spring	surface	120	96	132	160
Urea......	early spring	surface	120	80	106	166
Ammonium nitrate....	early June	surface	120	106	151	187
Urea......	early June	surface	120	99	125	132

Table 45. — Effect of Source and Rate of Spring-Applied Nitrogen on Corn Yield, DeKalb

Carrier	N (lb./acre)	Year 1976	Year 1977	Avg.
		Yield (bu./acre)		
None..................	0	66	61	64
Ammonia..............	80	103	138	120
28 pct. N solution incorporated..............	80	98	132	115
28 pct. N solution unincorporated............	80	86	126	106
Ammonia..............	160	111	164	138
28 pct. N solution incorporated..............	160	107	157	132
28 pct. N solution unincorporated............	160	96	155	126
Ammonia..............	240	112	164	138
28 pct. N solution incorporated..............	240	101	164	132
28 pct. N solution unincorporated............	240	91	153	122
	FLSD.10	9.1	5.2	

application of urea for zero-till corn did not yield as well as ammonium nitrate (Table 44) in most years. In years in which a rain was received within one or two days after application, urea resulted in as good a yield increase as did ammonium nitrate (that is, compared to results from early spring application of ammonium nitrate at Dixon Springs in 1975). In other studies, urea that was incorporated soon after application yielded as well as ammonium nitrate.

Nitrogen solutions. The non-pressure nitrogen solutions that contain 28 or 32 percent of nitrogen consist of a mixture of urea and ammonium nitrate. Typically, half of the nitrogen is from urea and the other half is from ammonium nitrate. The constituents of these compounds will undergo the same reactions as described above for the constituents applied alone.

Recent experiments at DeKalb have shown a yield difference between incorporated and unincorporated nitrogen solutions which were spring-applied (Table 45). This difference in yield associated with method of application is probably caused by the volatilization loss of some nitrogen from the surface-applied solution containing urea.

Phosphorus and Potassium

Inherent Availability

Illinois has been divided into three regions in terms of inherent phosphorus-supplying power of the soil below the plow layer in dominant soil types (Fig. 12).

High phosphorus-supplying power means that the soil test for available phosphorus (P_1 test) is relatively high and conditions are favorable for good root penetration and branching throughout the soil profile.

Low phosphorus-supplying power may be caused by one or more of these factors:

1. A low supply of available phosphorus in the soil profile because (a) the parent material was low in P; (b) phosphorus was lost in the soil-forming process; or (c) the phosphorus is made unavailable by high pH (calcareous) material.
2. Poor internal drainage that restricts root growth.
3. A dense, compact layer that inhibits root penetration or branching.
4. Shallowness to bedrock, sand, or gravel.
5. Drouthiness, strong acidity, or other conditions that restrict crop growth and reduce rooting depth.

Regional differences in phosphorus-supplying power are shown in Figure 12. Parent material and degree of weathering were the primary factors considered in determining the various regions.

The "High" region occurs in western Illinois, where the primary parent material was more than 4 to 5 feet of loess that was high in phosphorus content. The soils are leached of carbonates to a depth of more than 3½ feet, and roots can spread easily in the moderately permeable profiles.

The "Medium" region occurs in central Illinois with an arm extending into northern Illinois and a second arm extending into southern Illinois. The primary parent material was more than 3 feet of loess over glacial till, glacial drift, or outwash. Some sandy areas with low phosphorus-supplying power occur in the region. Compared with the high-phosphorus region, more of the soils are poorly drained and have less available phosphorus in the subsoil and substratum horizons. Carbonates are likely to occur at shallower depths than in the "High" region. The soils in the northern and central areas are generally free of root restrictions. Soils in the southern arm are more likely to have root-restricting layers within the profile. Phosphorus-supplying power of soils of the region is likely to vary with natural drainage. Soils with good internal drainage are likely to have high available P levels in the subsoil and substratum. If internal drainage is fair or poor, P levels in the subsoil and substratum are likely to be low or medium.

In the "Low" region in southeastern Illinois, the soils were formed from 2½ to 7 feet of loess over weathered Illinoian till. The profiles are more highly weathered than in the other regions and are slowly or very slowly permeable. Root development is more restricted than in the "High" and "Medium" regions. Subsoil phosphorus levels may be rather high by soil test in some soils of the region, but this is partially offset by conditions that restrict rooting.

In the "Low" region in northeastern Illinois, the soils were formed from thin (less than 3 feet) loess over glacial till. The glacial till, generally low in available phosphorus, ranges in texture from gravelly loam to clay in various soil associations of the region. In addition, shallow carbonates further reduce the phosphorus-supplying power of the soils of the region. High bulk density and slow permeability in the subsoil and substratum restrict rooting in many soils of the region.

The three regions are separated to show broad differences between them. Parent material, degree of weathering, native vegetation, and natural drainage vary within a region and cause variation in phosphorus-supplying power. It appears, for example, that soils developed under forest cover have more available subsoil phosphorus than those developed under grass.

Illinois is divided into two general regions based on potassium-supplying power (Fig. 13). There are, however, important differences among soils within these general regions because of differences in the seven factors listed below.

1. The amount of clay and organic matter. This influences the exchange capacity of the soil.
2. The degree of weathering of the soil material. This affects the amount of potassium that has been leached out.
3. The kind of clay mineral.
4. Drainage and aeration. These influence K uptake.
5. The amount of calcium and magnesium. Very high calcium and magnesium may reduce K uptake.
6. The parent material from which the soil formed.
7. Compactness or other conditions that influence root growth.

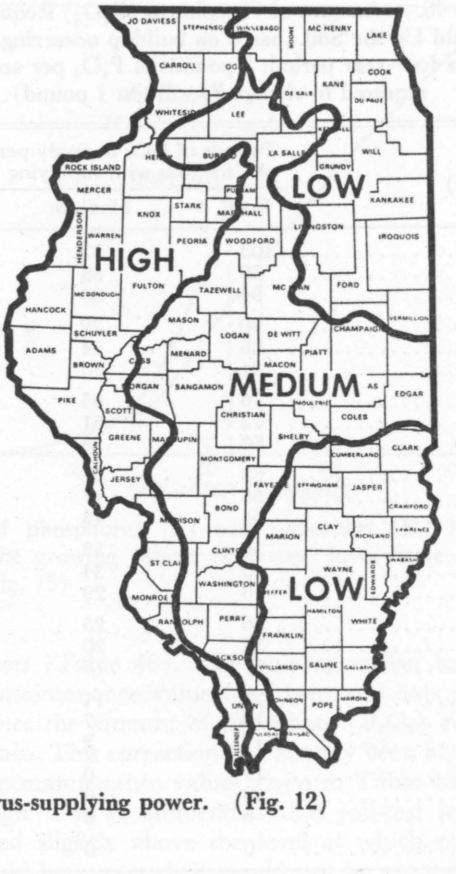
Soils having a cation-exchange capacity less than 12 me./100 g. are classified as having low potassium-supplying power. These include the sandy soils since minerals from which these soils developed are inherently low in K. Sandy soils also have very low cation-exchange capacities and thus do not hold much reserve K.

Silt-loam soils in the "Low" area in southern Illinois (claypans) are relatively older soils in terms of soil development; consequently, much more of the potassium has been leached out of the rooting zone. Furthermore, wetness and a platy structure between the surface and subsoil may interfere with rooting and with K uptake early in the growing period, even though roots are present.

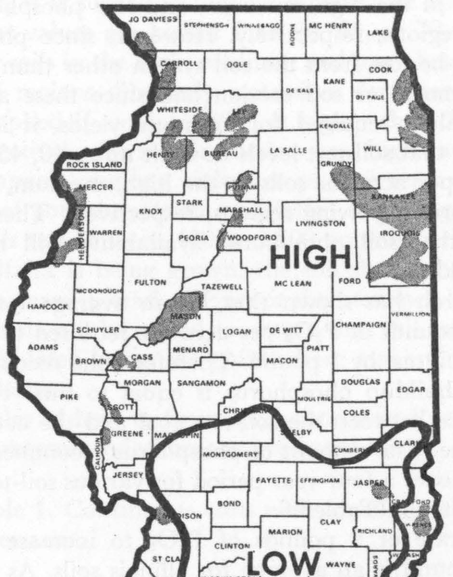
Rate of Fertilizer Application

Buildup. Certain minimum phosphorus and potassium levels are needed in order to produce optimum crop yields.

Near maximum yields of corn and soybeans will be obtained when available phosphorus levels are maintained at 30, 40, and 45 pounds of phosphorus per acre



Phosphorus-supplying power. (Fig. 12)



Potassium-supplying power. The shaded areas are sands with low potassium-supplying power. (Fig. 13)

Table 46. — Amount of Phosphorus (P_2O_5) Required To Build Up the Soil (based on buildup occurring over a four-year period; 9 pounds of P_2O_5 per acre required to change P_1 soil test 1 pound)

P_1 test (lb./acre)	Pounds of P_2O_5 to apply per acre *each year* for soils with supplying power of: Low	Medium	High
4	103	92	81
6	99	88	76
8	94	83	72
10	90	79	68
12	86	74	63
14	81	70	58
16	76	65	54
18	72	61	50
20	68	56	45
22	63	52	40
24	58	47	36
26	54	43	32
28	50	38	27
30	45	34	22
32	40	29	18
34	36	25	14
36	32	20	9
38	27	16	4
40	22	11	0
42	18	7	0
44	14	2	0
45	11	0	0
46	9	0	0
48	4	0	0
50	0	0	0

for soils in the high, medium, and low phosphorus-supplying regions, respectively. However, since phosphorus will not be lost from the soil system other than through crop removal or soil erosion and since these are minimum values required for optimum yields, it is recommended that soil-test levels be built up to 40, 45, and 50 pounds per acre for soils in the high, medium, and low phosphorus-supplying regions, respectively. These values ensure that soil phosphorus availability will not limit crop yield.

Research has shown that, as an average for Illinois soils, 9 pounds of P_2O_5 per acre are required to increase the P_1 soil test by 1 pound. Therefore, the recommended rate of buildup phosphorus is equal to nine times the difference between the soil-test goal and the actual soil-test value. The amount of phosphorus recommended for buildup over a four-year period for various soil-test levels is presented in Table 46.

The rate of 9 pounds of P_2O_5 to increase the soil test 1 pound is an average for Illinois soils. As a result, some soils will fail to reach the desired goal in four years with P_2O_5 applied at this rate and others will exceed the goal. Therefore, it is recommended that each field be retested every four years.

The only significant loss of soil-applied potassium is through crop removal or soil erosion. Therefore, it is recommended that soil-test potassium be built up to values of 260 and 300 pounds of exchangeable potassium, respectively, for soils in the low- and high-cation-exchange capacity region. These values are slightly higher than that required for maximum yield, but as in the phosphorus recommendations this will ensure that potassium availability will not limit crop yields.

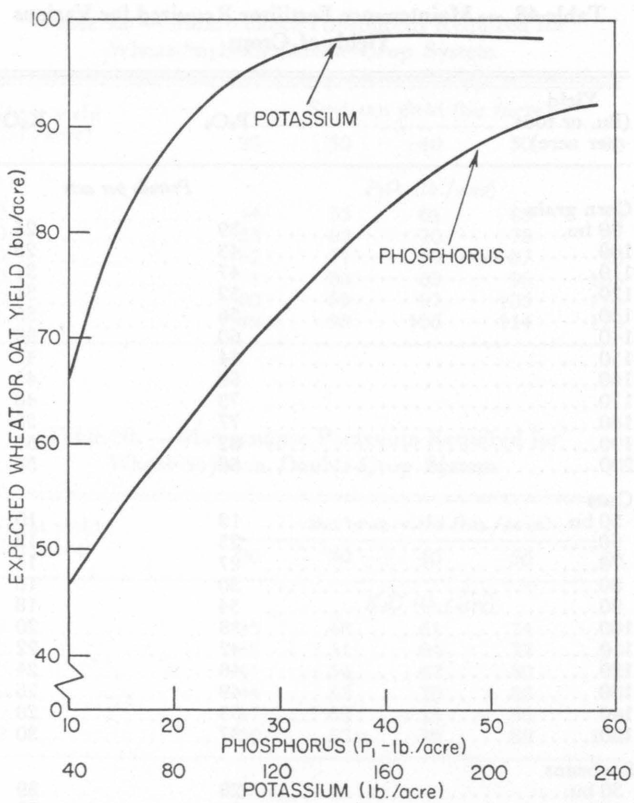
Research has shown that 4 pounds of K_2O are required, on the average, to increase the soil test 1 pound. Therefore, the recommended rate of potassium application for increasing the soil-test value to the desired goal is equal to four times the difference between the soil-test goal and the actual soil-test value. Tests on soil samples that are taken before May 1 or after September 30 should be adjusted downward as follows: subtract 30 for dark-colored soils in central Illinois; subtract 45 for light-colored soils in central and northern Illinois; subtract 60 for medium- and light-colored soils in southern Illinois; subtract 45 for fine-textured bottomland soils. Annual potassium application rates recommended for a four-year period for various soil test values are presented in Table 47.

Table 47. — Amount of Potassium (K_2O) Required To Build Up the Soil (based on the buildup occurring over a four-year period; 4 pounds of K_2O per acre required to change the K test 1 pound)

K test[a] (lb./acre)	Amount of K_2O to apply per acre *each year* for soils with cation exchange capacity: Low[b]	High[b]
50	210	250
60	200	240
70	190	230
80	180	220
90	170	210
100	160	200
110	150	190
120	140	180
130	130	170
140	120	160
150	110	150
160	100	140
170	90	130
180	80	120
190	70	110
200	60	100
210	50	90
220	40	80
230	30	70
240	20	60
250	10	50
260	0	40
270	0	30
280	0	20
290	0	10
300	0	0

[a] Tests on soil samples that are taken before May 1 or after September 30 should be adjusted downward as follows: subtract 30 pounds for dark-colored soils in central Illinois; 45 pounds for light-colored soils in central and northern Illinois, and fine-textured bottomland soils; and 60 pounds for medium- and light-colored soils in southern Illinois.

[b] The low cation-exchange capacity corresponds to soil areas designated low in potassium-supplying power, while high cation-exchange-capacity soils are those formerly designated medium to high in potassium-supplying power. Low cation-exchange-capacity soils would be those with CEC less than 12 me./100 g. soil, and high would be those equal to or greater than 12 me./100 g. soil.

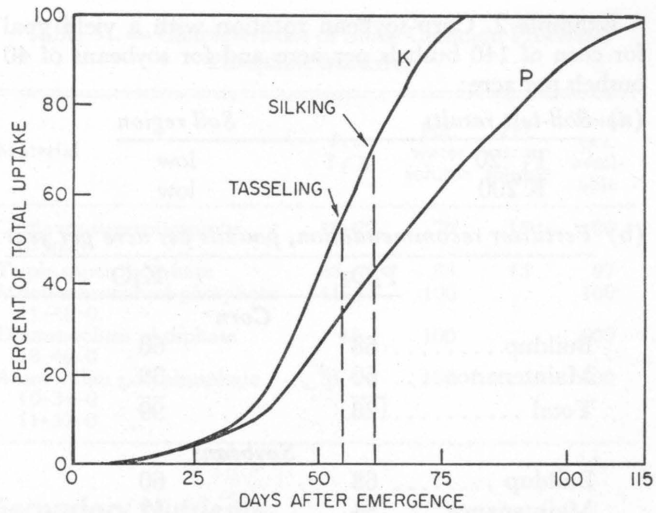


Relationship between expected wheat or oat yield and soil-test phosphorus and potassium. (Fig. 14)

In addition to the supplying power of the soil, the optimum soil-test value also is influenced by the crop to be grown. For example, the phosphorus soil-test level required for optimum wheat and oat yield is considerably higher than that for corn or soybeans, and the optimum level is the same irrespective of the phosphorus-supplying ability of the soil (Fig. 14). One reason for this difference in requirement is in part the different phosphorus uptake patterns of wheat and corn. Wheat requires a large amount of readily available phosphorus in the fall, when the plant root system is feeding primarily from the upper soil surface. Phosphorus is taken up by corn until the grain is fully developed (Fig. 15), so subsoil phosphorus is more important in interpreting the phosphorus test for corn than for wheat. To compensate for the higher phosphorus requirements of wheat and oats, it is suggested that 1.5 times the maintenance application be applied prior to seeding them.

Wheat is not very responsive to potassium unless the soil test is less than 100. However, since wheat is usually grown in rotation with corn and soybeans, it is suggested that soils be maintained at the optimum available potassium level for corn and soybeans.

Maintenance. In addition to adding fertilizer to build up the soil test, sufficient fertilizer should be added each year to maintain a specified soil-test level. The amount of fertilizer required to maintain the soil-test value is equal to the amount removed by the harvested portion



Uptake of phosphorus (P) and potassium (K) by corn through the growing season (Hanway, Iowa State University). (Fig. 15)

of the crop (Table 48). The only exception to this is that the maintenance value for wheat and oats is equal to 1.5 times the amount of phosphate (P_2O_5) removed by the grain. This correction has already been accounted for in the maintenance values given in Table 48.

Although it is recommended that soil-test levels be maintained slightly above the level at which optimum yield would be expected, it would not be economical to attempt to maintain the values at excessively high levels. Therefore, it is suggested that no fertilizer be applied if P_1 soil-test values are higher than 60, 65, or 70, respectively, for soils in the high, medium, and low phosphorus-supplying regions. Similarly, potassium fertilizer should not be applied if available "K" is higher than 360 and 400, respectively, for soils in the low and high cation-exchange-capacity regions, unless crops that remove large amounts of potassium (such as alfalfa) are being grown. When soils test between 400 and 600 pounds per acre of K and alfalfa is being grown, the soil should be tested every two years instead of four, or maintenance levels of potassium should be added to ensure that soil test levels are not depleted below the point where maximum yields will be obtained.

Examples of how to figure phosphorus and potassium fertilizer recommendations are presented below.

Example 1. Continuous corn with a yield goal of 140 bushels per acre:

(a)

Soil-test results	*Soil region*
P_1 30	high
K 250	high

(b) *Fertilizer recommendation, pounds per acre per year*

	P_2O_5	K_2O
Buildup	22 (Table 46)	50 (Table 47)
Maintenance	60 (Table 48)	39 (Table 48)
Total..........	82	89

Example 2. Corn-soybean rotation with a yield goal for corn of 140 bushels per acre and for soybeans of 40 bushels per acre:

(a) *Soil-test results* — *Soil region*

Soil-test results	Soil region
P_1 20	low
K 200	low

(b) *Fertilizer recommendation, pounds per acre per year*

	P_2O_5	K_2O
Corn		
Buildup	68	60
Maintenance	60	39
Total	128	99
Soybeans		
Buildup	68	60
Maintenance	34	52
Total	102	112

Note that buildup recommendations are independent of the crop to be grown, but maintenance recommendations are directly related to the crop to be grown and the yield goal for the particular crop.

Example 3. Continuous corn with a yield goal of 150 bushels per acre:

(a) *Soil-test results* — *Soil region*

Soil-test results	Soil region
P_1 90	low
K 420	low

(b) *Fertilizer recommendation, pounds per acre per year*

	P_2O_5	K_2O
Buildup	0	0
Maintenance	0	0
Total	0	0

Note that soil-test values are higher than those suggested; thus, no fertilizer would be recommended. Retest the soil after four years to determine fertility needs.

For farmers planning to double crop soybeans after wheat, it is suggested that phosphorus and potassium fertilizer required for both the wheat and soybeans be applied prior to seeding the wheat. This practice will reduce the number of field operations necessary at planting time and will hasten the planting operation.

The maintenance recommendations for phosphorus and potassium in a double-crop wheat and soybean system are presented in Tables 49 and 50, respectively. Assuming a wheat yield of 50 bushels per acre followed by a soybean yield of 30 bushels per acre, the maintenance recommendation would be 71 pounds of P_2O_5 and 54 pounds of K_2O per acre.

Time of Application

Although the fertilizer rates for buildup and maintenance in Tables 46 through 48 are for an annual application, producers may apply enough nutrients in any one year to meet the needs of the crops to be grown in the succeeding two- to three-year period.

Table 48. — Maintenance Fertilizer Required for Various Yields of Crops

Yield (Bu. or tons per acre)	P_2O_5	K_2O
	Pounds per acre	
Corn grain		
90 bu.	39	25
100	43	28
110	47	31
120	52	34
130	56	36
140	60	39
150	64	42
160	69	45
170	73	48
180	77	50
190	82	53
200	86	56
Oats		
50 bu.	19	10
60	23	12
70	27	14
80	30	16
90	34	18
100	38	20
110	42	22
120	46	24
130	49	26
140	53	28
150	57	30
Soybeans		
30 bu.	26	39
40	34	52
50	42	65
60	51	78
70	60	91
80	68	104
90	76	117
100	85	130
Corn silage		
90 bu.; 18T	48	126
100; 20	53	140
110; 22	58	154
120; 24	64	168
130; 26	69	182
140; 28	74	196
150; 30	80	210
Wheat		
30 bu.	27	9
40	36	12
50	45	15
60	54	18
70	63	21
80	72	24
90	81	27
100	90	30
110	99	33
Alfalfa, grass, or alfalfa-grass mixtures		
2T	24	100
3	36	150
4	48	200
5	60	250
6	72	300
7	84	350
8	96	400
9	108	450
10	120	500

For perennial forage crops, broadcast and incorporate all of the buildup and as much of the maintenance phosphorus as economically feasible prior to seeding. On low-fertility soils, apply 30 pounds of phosphate (P_2O_5) per

Table 49. — Maintenance Phosphorus Required for Wheat-Soybean Double-Crop System

Wheat yield (bu./acre)	Soybean yield (bu./acre) 20	30	40	50	60
	P_2O_5 (*lb./acre*)				
30	44	53	61	69	78
40	53	62	70	78	87
50	62	71	79	87	96
60	71	80	88	96	105
70	80	89	97	105	114
80	89	98	106	114	123

Table 50. — Maintenance Potassium Required for Wheat-Soybean Double-Crop System

Wheat yield (bu./acre)	Soybean yield (bu./acre) 20	30	40	50	60
	K_2O (*lb./acre*)				
30	35	48	61	74	87
40	38	51	64	77	90
50	41	54	67	80	93
60	44	57	70	83	96
70	47	60	73	86	99
80	50	63	76	89	102

acre using a band seeder. If a band seeder is used, you may safely apply a maximum of 30 to 40 pounds of potash (K_2O) per acre in the band with the phosphorus. Up to 300 pounds of K_2O per acre can be safely broadcast in the seedbed without damaging seedlings.

Topdress applications of phosphorus and potassium on perennial forage crops may be applied at any convenient time. Usually this will be after the first harvest or in September.

High Water Solubility of Phosphorus

The water solubility of the P_2O_5 listed as available on the fertilizer label is of little importance under typical field crop and soil conditions on soils with medium to high levels of available phosphorus, when recommended rates of application and broadcast placement are used.

There are some exceptions when water solubility is important. These include the following:

1. For band placement of a small amount of fertilizer to stimulate early growth, at least 40 percent of the phosphorus should be water soluble for application to acid soils and preferably 80 percent for calcareous soils. As shown in Table 51, the phosphorus in nearly all fertilizers commonly sold in Illinois is highly water soluble. Phosphate water-solubility in excess of 75 to 80 percent has not been shown to give further yield increases above those that have water-solubility levels of 50 to 80 percent.

2. For calcareous soils, a high degree of water solubility is desirable, especially on soils that are shown by soil test to be low in available phosphorus.

Table 51. — Characteristics of Some Common Processed Phosphate Materials

Material	Pct. P_2O_5	Pct. water soluble	Pct. citrate soluble	Total pct. available
Ordinary superphosphate 0–20–0	16–22	78	18	96
Triple superphosphate	44–47	84	13	97
Mono-ammonium phosphate 11–48–0	46–48	100	..	100
Diammonium phosphate 18–46–0	46	100	..	100
Ammonium polyphosphate 10–34–0 11–37–0	34–37	100	..	100

Secondary Nutrients

The elements that are classified as secondary nutrients include calcium, magnesium, and sulfur. Deficiency of calcium has not been recognized in Illinois where soil pH is 5.5 or above. Calcium deficiency associated with acid soils should be corrected by the use of limestone adequate to correct the soil pH.

Magnesium deficiency has been recognized in isolated situations in Illinois. Although the deficiency is usually associated with acid soils, there have been instances of low magnesium reported on sandy soils where the soils were not excessively acid. The soils most likely to be deficient in magnesium include sandy soils throughout Illinois and low-exchange capacity soils of southern Illinois. Deficiency will be more likely where calcitic rather than dolomitic limestone has been used and where potassium test levels have been high (above 400). Suggested soil test magnesium levels are 60-75 pounds per acre on sandy soils and 120-150 pounds per acre on silt loam or finer textured soils for grain crops.

Recognition of sulfur deficiency has been reported with increasing frequency throughout the Midwest. These deficiencies probably are occurring because of (1) increased use of S-free fertilizer, (2) decreased use of sulfur as a fungicide and insecticide, (3) increased crop yields, resulting in increased requirements for all of the essential plant nutrients, and (4) decreased atmospheric sulfur supply.

Organic matter is the primary source of sulfur in soils. Thus soils low in organic matter are more likely to be deficient than are soils with a high level of organic matter. Since sulfur is very mobile and can be readily leached, deficiency is more likely to be found on sandy soils than on finer textured soils.

A statistically significant yield response to sulfur application was observed at 5 out of 87 locations in Illinois (Table 52). Two of these responding sites, one an eroded silt loam and one a sandy soil, were found in northwestern Illinois (Whiteside and Lee Counties); one site, a silty clay loam, was found in central Illinois (Sangamon County); and two sites, one a silt loam and one a sandy loam soil, were found in southern Illinois (Richland and White Counties).

At the responding sites, sulfur treatments resulted in corn yields that averaged 11.2 bushels per acre more than yields from the untreated plots. At the nonresponding sites, yields from the sulfur-treated plots averaged only 0.5 bushel per acre more than those from the untreated plots (Table 52). If one considers only the responding sites, the sulfur soil test predicts with good reliability which sites will respond to sulfur applications. Of the 5 responding sites, 1 had only 12 pounds of sulfur per acre, less than the amount considered necessary for normal plant growth, and 3 had marginal sulfur concentration (from 12 to 20 pounds of sulfur per acre). Sulfur tests on the 80 nonresponding sites showed 14 to be deficient and 29 to have a level of sulfur that is considered marginal for normal plant growth. However, sulfur applications produced no significant positive response in these plots. The correlation between yield increases and measured sulfur soil levels was very low, indicating that the sulfur soil test did not reliably predict sulfur need.

In addition to soil test values, one should also consider organic matter level, potential atmospheric sulfur contributions, subsoil sulfur content, and moisture conditions just prior to soil sampling in determining whether a sulfur response is likely. If organic matter levels are greater than 2.5 percent, use sulfur on a trial basis even when the soil test reading is low. If the field in question is located in an area downwind from industrial operations where significant amounts of sulfur are being emitted, use sulfur on a trial basis even when the soil test reading is low. Since sulfur is a mobile nutrient supplied principally by organic matter oxidation, abnormal precipitation (either high or low) could adversely affect the sulfur status of samples taken from the soil surface. If precipitation has been high just prior to sampling, some samples may have a low reading due to leaching. If precipitation were low and temperatures warm, some soils may have a high reading when in fact the soil is not capable of supplying adequate amounts of sulfur throughout the growing season.

Micronutrients

The elements that are classified as essential micronutrients include zinc, iron, manganese, copper, boron, molybdenum, and chlorine. These nutrients are classified as micronutrients because they are required in small (micro) amounts. Confirmed deficiences of these micronutrients in Illinois have been limited to boron deficiency of alfalfa, zinc deficiency of corn, and iron and manganese deficiency of soybeans.

Manganese deficiency (stunted plants with green veins in yellow or whitish leaves) is common on high-pH (alkaline), sandy soils, especially during cool, wet weather in late May and June. Suggested treatment is to spray 10 pounds of manganese sulfate (containing 2.5 pounds of manganese) per acre in 25 gallons of water when the beans are 6 to 10 inches tall. If the spray is directed on the row, the rate can be cut in half. Some fertilizer dealers have other manganese formulations that you can apply according to instructions. Broadcast application on the soil is ineffective because the manganese becomes unavailable in soils with a high pH.

Table 52. — Average Yields at Responding and Nonresponding Zinc and Sulfur Test Sites, 1977–79

	Number of sites	Yield from untreated plots	Yield from zinc-treated plots	Yield from sulfur-treated plots
		Bushels per acre		
Responding sites				
Low-sulfur soil	5	140.0	....	151.2
Low-zinc soil	3	150.6	164.7	....
Nonresponding sites ..	80	147.6	146.2	148.2

Wayne and Hark soybean varieties often show iron deficiency on soils with a very high pH (usually 7.4 to 8.0). The symptoms are similar to manganese deficiency. Most of the observed deficiencies have been on Harpster, a "shelly" soil that occurs in low spots in some fields in central and northern Illinois. This problem has appeared on Illinois farms only since the Wayne variety was introduced in 1964.

Soybeans often outgrow the stunted, yellow appearance of iron shortage. As a result, it has been difficult to measure yield losses or decide whether or how to treat affected areas. Sampling by U.S. Department of Agriculture scientists in 1967 indicated yield reductions of 30 to 50 percent in the center of severely affected spots. The yield loss may have been caused by other soil factors associated with a very high pH and poor drainage, rather than by iron deficiency itself. Several iron treatments were ineffective in trials near Champaign and DeKalb in 1968.

Recent research in Minnesota has shown that time of iron application is critical if an effective control is to be attained. Researchers recommend that a rate of 0.15 pound iron per acre as iron chelate be applied to leaves within 3 to 7 days after chlorosis symptoms develop (usually in the second trifoliate stage of growth). Waiting for soybeans to grow to the fourth or fifth trifoliate stage before applying iron did not result in a yield increase. Because iron applied to the soil surface between rows does not help, directed applications directly over the soybean plants are preferred.

A significant yield response to zinc applications was observed at 3 out of 85 sites evaluated in Illinois (Table 52). The use of zinc at the responding sites produced a corn yield that averaged 14.1 bushels per acre more than in the check plots. Two sites were Fayette silt loams in Whiteside County, and one was a Greenriver sand in Lee County.

At two of the three responding sites, tests showed that the soil was low or marginal in available zinc. The soil of the third had a very high zinc level but was deficient in available zinc, probably because of the excessively high phosphorus level also found at that site.

The soil-test procedures accurately predicted results for two-thirds of the responding sites. However, the same tests incorrectly predicted that 19 other sites would respond. These results suggest that the soil test for available zinc can indicate where zinc deficiencies are found but does not indicate reliably whether the addition of zinc will increase yields.

In order to identify areas before micronutrient deficiencies become important, we need to continually observe the most sensitive crops in soil situations in which the elements are most likely to be deficient (Table 53).

In general, deficiencies of most micronutrients are accentuated by one of five situations: (1) strongly weathered soils, (2) coarse-textured soils, (3) soils high in pH, (4) organic soils, and (5) soils inherently low in organic matter or low in organic matter because of removal of topsoil by erosion or land-shaping processes.

The use of micronutrient fertilizers should be limited to the application of specific micronutrients to areas of known deficiency. Only the deficient nutrient should be applied. An exception to this would be when farmers already in the highest yield bracket try micronutrients on an experimental basis in fields that are yielding less than would be expected under good management, which includes an adequate nitrogen, phosphorus, and potassium fertility program and a favorable pH.

Method of Fertilizer Application

Broadcast and row fertilization. On high-fertility soils, both maintenance and buildup phosphorus will be efficiently utilized when broadcast and plowed or disked in. However, on low-fertility soils it would be advisable to broadcast the buildup fertilizer and apply the maintenance fertilizer in the row. Farmers in central and northern Illinois who plant early may find it advantageous to apply some row fertilizer for promotion of early vigorous growth in soils that remain cool and wet in early spring.

"Pop-up" fertilization. "Pop-up" fertilizer will make corn look very good early in the season and may aid in early cultivation for weed control. But there is not likely to be a substantial difference in yield produced in most years by a "pop-up" application or by fertilizer that is placed in a band to the side and below the seed. With these two placements there seldom will be a difference of more than a few days in the time the root system intercepts the fertilizer band.

"Pop-up" fertilization means placing 40 to 50 pounds of fertilizer per acre in contact with the seed. Research in many states over a long period of time has shown that, for starter effect only, you should place fertilizer as close to the seed as safety permits. The tube from the fertilizer hopper is positioned to do this; the fertilizer is not mixed with the seed prior to planting.

"Pop-up" fertilizer should contain all three major nutrients in a ratio of about 1-4-2 of N-P_2O_5-K_2O (1-1.7-1.7 of N-P-K). The maximum safe amount of N + K_2O for "pop-up" placement is about 10 to 12 pounds per acre in 40-inch rows and correspondingly more in 30- and 20-inch rows. It is, in fact, necessary to apply more in narrow rows to have an equal amount per foot of row.

The term "pop-up" is a misnomer. The corn does not emerge sooner than it does without this kind of application, and it may come up 1 or 2 days later. The corn may, however, grow more rapidly during the first 1 to 2 weeks after emergence.

Table 53. — Soil Situations and Crops Susceptible to Micronutrient Deficiency

Micronutrient	Sensitive crop	Susceptible soil situations	Season favoring deficiency
Zinc (Zn)	Young corn	1. Low organic matter either inherent or because of erosion or land shaping 2. High pH, i.e. >7.3 3. Very high phosphorus 4. Restricted root zone 5. Coarse textured (sandy) 6. Organic soils	Cool, wet
Iron (Fe)	Wayne soybeans, grain sorghum	1. High pH	Cool, wet
Manganese (Mn)	Soybeans, oats	1. High pH 2. Restricted root zone 3. Organic soils	Cool, wet
Boron (B)	Alfalfa	1. Low organic matter 2. High pH 3. Strongly weathered soils in south-central Illinois 4. Coarse textured (sandy)	Drought
Copper (Cu)	Corn	1. Infertile sand 2. Organic soils	Unknown
Molybdenum (Mo)	Soybeans	1. Strongly weathered soils in south-central Illinois	Unknown
Chlorine (Cl)	Unknown	1. Coarse-textured soils	Excessive leaching by low Cl water

Table 54. — Yields of Corsoy and Amsoy Soybeans After Fertilizer Treatments Were Sprayed to the Foliage Four Times, Urbana

Treatment per spraying, lb./acre				Yield, bu./acre	
N	P_2O_5	K_2O	S	Corsoy	Amsoy
0	0	0	0	61	56
20	0	0	0	54	53
0	5	8	1	58	56
10	5	8	1	56	58
20	5	8	1	55	52
30	7.5	12	1.5	52	46

"Pop-up" fertilizer is unsafe for soybeans. In research conducted at Dixon Springs by George McKibben, a stand was reduced to one-half by applying 50 pounds of 7-28-14 and to one-fifth with 100 pounds of 7-28-14.

Foliar fertilization. Researchers have known for many years that plant leaves absorb and utilize nutrients sprayed on them. Foliar fertilization has been successfully used for certain crops and nutrients. This method of application has had the greatest use with nutrients required in only small amounts by plants. Nutrients required in large amounts, such as nitrogen, phosphorus, and potassium, have usually been applied to the soil rather than to plant foliage.

The possible benefit of foliarly applied nitrogen fertilizer was researched at the University of Illinois in the 1950's. Foliarly applied nitrogen increased corn and wheat yield, provided that the soil was deficient in nitrogen. Where adequate nitrogen was applied to the soil, additional yield increases were not obtained from foliar fertilization.

Additional research in Illinois was conducted on foliar application of nitrogen to soybeans in the 1960's. This effort was an attempt to supply additional nitrogen to soybeans without decreasing nitrogen symbiotically fixed. That is, it was thought that if nitrogen application was delayed until after nodules were well established, then perhaps symbiotic fixation would remain active. Single or multiple applications of nitrogen solution to foliage did not increase soybean yields. Damage to vegetation occurred in some cases because of leaf "burn" caused by the nitrogen fertilizer.

Although considerable foliar fertilization research had been conducted earlier in Illinois, new research was conducted in 1976 and 1977. This new research was prompted by a report from a neighboring state which indicated that soybean yields had recently been increased by as much as 20 bushels per acre in some trials. Research in that state differed from our earlier work on soybeans in that, in addition to nitrogen, the foliar fertilizer increased yield only if phosphorus, potassium, and sulfur were also included. Researchers there thought that soybean leaves became deficient in nutrients as nutrients were translocated from vegetative parts to the grain during grain development. They reasoned that foliar fertilization, which would prevent leaf deficiencies, should result in increased photosynthesis that would be expressed in higher grain yields.

Foliar fertilization was conducted at several locations in Illinois during 1976 and 1977 — ranging from Dixon Springs in southern Illinois to DeKalb in northern Illinois. None of the experiments gave economical yield increases. In some cases there were yield reductions, which were attributed to leaf damage caused by the fertilizer. Table 54 contains data from a study at Urbana where soybeans were sprayed four times with various fertilizer solutions. Yields were not increased by foliar fertilization.

Fertility "Quacks" Get New Life

It seems hard to believe that in this day of better informed farmers the number of letters, calls, and promotional leaflets about completely unproven products is increasing. The claim is usually that Product X either replaces fertilizers and costs less, makes nutrients in the soil more available, supplies micronutrients, or is a natural product that does not contain strong acids that kill soil bacteria and earthworms.

The strongest position that legitimate fertilizer dealers, extension advisers, and agronomists can take is to challenge these peddlers to produce unbiased research results to support their claims. Farmer testimonials are no substitute for research.

Agronomists can often refute the specific claims of the quacks on theory and with research results, but then the quacks come up with new claims or fall back on the old cliche, "We don't know why it works, but it does." No one can effectively argue with the farmer who says, "It works on my farm." Dozens of research trials on the same kind of soil are no match for the simple statement, "It works for me." That is what is so frustrating to dealers, agronomists, and extension advisers, and so dangerous to farmers who depend upon farmer testimonials for unproven products.

Extension specialists at the University of Illinois are ready to give unbiased advice when asked about purchasing new products or accepting a sales agency for them.

SOIL MANAGEMENT AND TILLAGE SYSTEMS

Intensive use of a moldboard plow, disk, harrow, and cultivator was once the only practical tillage system that could give the crop producer reasonable assurance of establishing a crop and controlling weeds. Modern herbicides and implements have made alternatives to the traditional intensive tillage system possible. When choosing a tillage system, one should consider crop yields, costs, and soil erosion. With these areas in mind, one must evaluate the tillage method as it relates to soil type, slope, drainage, and temperature, timeliness, and fertilizer distribution, and each method's potential for weed, insect, and disease control.

The following four sections describe tillage systems used in Illinois and list some advantages and disadvantages of each.

Moldboard Plow System

(Conventional Clean Tillage)

Primary tillage is done with a moldboard plow. Secondary tillage includes one or more operations with a disk, field cultivator, harrow, or similar implement.

Advantages

1. The uniform fine seedbed gives good seed-soil contact and easy planting.
2. Insecticides and herbicides are most effective in a uniform, fine seedbed that is free of crop residues.
3. Survival of some insects, especially European corn borer, is reduced because corn stalk residues are buried.
4. The system is flexible and adaptable to a wide range of soil and crop conditions.
5. Use of labor and machinery is reasonably well distributed with fall plowing.
6. Yields are as high as or higher than with alternative tillage systems over a wide range of soil and weather conditions.
7. A wide selection of herbicides can be used, and weed control is usually better than with alternative tillage systems.

Disadvantages

1. Bare soil is very susceptible to wind and water erosion.
2. Soil crusting is often a problem with a uniform fine seedbed.
3. Fuel consumption and machinery costs are high.

Chisel Plow System

Primary tillage is done with a chisel plow, usually in the fall, followed by use of a disk or field cultivator in the spring.

Advantages

1. Machinery costs are slightly lower than with moldboard plowing due to lower energy requirements per acre.
2. The soil surface is rough and partially covered by crop residues that reduce raindrop impact and runoff, resulting in more water infiltration and less soil erosion.
3. Soil roughness and residues protect the soil from wind erosion.
4. Less time is required for primary tillage compared to that for moldboard plowing.
5. Yields are comparable to other tillage systems, especially on well-drained soils. On poorly drained soils, the chisel plow system can be used for at least three or four years before moldboard plowing without any significant yield decrease.

Disadvantages

1. If secondary tillage is incomplete, a heavy planter with disk openers and a coulter in front of each row may be needed for planting in rough, residue-covered soil.
2. Soil temperatures are lower, especially on poorly drained soils, resulting in slightly slower early corn growth in the northern two-thirds of Illinois.
3. Stands are sometimes slightly lower than with conventional tillage.
4. A tractor must be available with adequate horsepower to pull a chisel plow.
5. Slightly higher herbicide rates may be required to give satisfactory weed control.
6. Crop residues on the soil surface may harbor insects and disease-causing organisms.
7. Erosion control may be lost in the spring if excessive spring tillage is used.

Disk System

A heavy disk is used for primary tillage in the fall or spring. A field cultivator or a light disk is used for secondary tillage. The general advantages and disadvantages of the chisel plow system apply to the disk system, provided that the disk is set to produce a rough soil surface covered with some crop residues.

No-Tillage System (Zero-Tillage)

Seed is planted in previously undisturbed soil by means of a special heavy planter equipped to plant through residue in firm soil. Fertilizers and pesticides must be applied to the soil surface or in the narrow, tilled area of the row. Weeds growing at planting are killed with a contact herbicide.

Advantages

1. Power, labor, and fuel costs are greatly reduced compared to those resulting from other tillage systems.
2. The planter can be used in crop residues, sod, or in a conventionally tilled seedbed.
3. Soil erosion is greatly reduced compared to that from other systems.
4. Plant residues on the soil surface reduce evaporation, conserving soil moisture for use by the crop.

Disadvantages

1. Low soil temperatures often delay emergence and cause slow early growth.
2. Special planting equipment is needed. It is difficult to get adequate seed-soil contact, a uniform planting depth, and uniform seed cover with most available planters.
3. Rodents and birds may reduce stands.
4. Some insect and crop disease problems may be enhanced when crop residues are left on the soil surface.
5. Weed control is entirely dependent on herbicides since cultivation is nearly impossible in heavy residues.
6. Higher herbicide rates or more costly herbicide combinations are usually needed for adequate weed control.
7. Water runoff is comparable to that from the moldboard plow system.

Soil Erosion and Tillage

Bare, smooth soil left by moldboard plowing and intensive secondary tillage is extremely susceptible to soil erosion. Many Illinois soils have subsurface layers that are unfavorable for root development. Soil erosion slowly but permanently removes the soil that is most favorable for crop growth, resulting in gradually decreasing soil productivity and value. Even on soils without root-restricting subsoils, erosion removes nutrients that must be replaced with additional fertilizer to maintain yields.

Sediment from eroding fields increases water pollution, reduces the storage capacity of lakes and reservoirs, and decreases the efficiency of drainage systems.

Effective erosion control systems usually include one or more of three features: (1) the soil is protected with a cover of vegetation, such as a mulch of crop residue; (2) the soil is tilled so that a maximum amount of water is absorbed with a minimum of runoff; (3) long slopes are divided into a series of short slopes so that the water cannot get "running room."

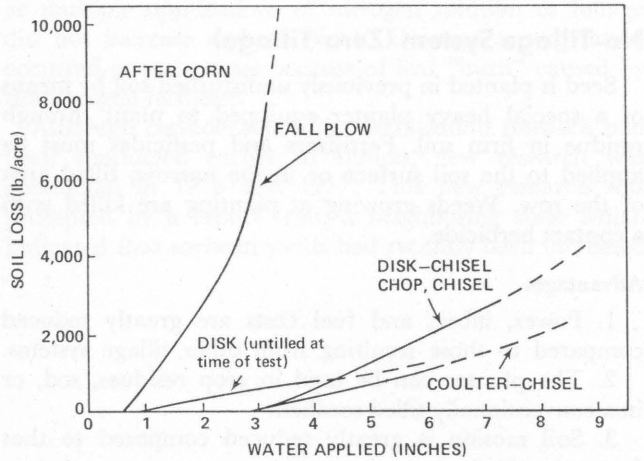
Chisel plow, no-tillage, and other tillage systems that leave a protective mulch of crop residues at the soil surface, or that leave the soil surface rough and porous, are often called conservation tillage systems. Figures 16 and 17 illustrate the effectiveness of these conservation tillage systems in reducing soil erosion from a 5-percent slope in simulated rainfall tests on a Catlin silt loam at Urbana. Nearly 1,000 pounds of soil per acre was lost from a moldboard-plowed area subjected to 1.25 inches of intense rain. Nearly 4 inches of water was required to erode that amount of soil where a chisel plow, disk, or no-tillage system was used. Soil erosion after soybeans was considerably greater than after corn, but conservation tillage resulted in greatly reduced soil loss compared to that from moldboard plowing.

Conservation tillage will not completely control water erosion on all soils; contouring is necessary for all tillage systems on sloping soils. Chisel plows, for example, often leave shallow furrows that can concentrate rainwater and erode severely if the tillage direction is uphill and down. Long or steep slopes may also require terraces or other practices. Contact your district conservationist, Soil Conservation Service for technical assistance in developing erosion control systems.

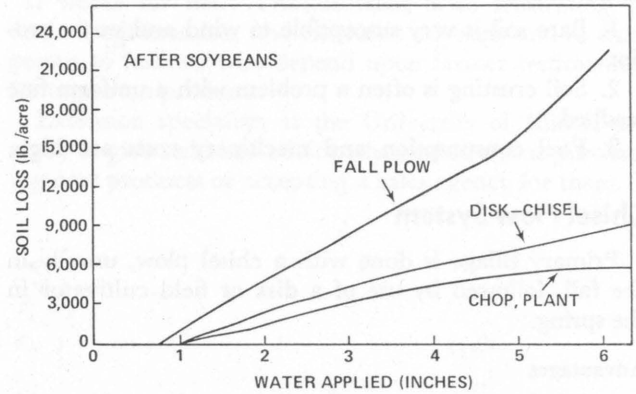
Water and Nutrient Losses

Water runoff starts earliest on soils with the smoothest surfaces, such as those created by moldboard plow, disk, and zero-tillage systems. Since the rough surface of chisel-plowed soil provides barriers to runoff, more water is required before runoff occurs.

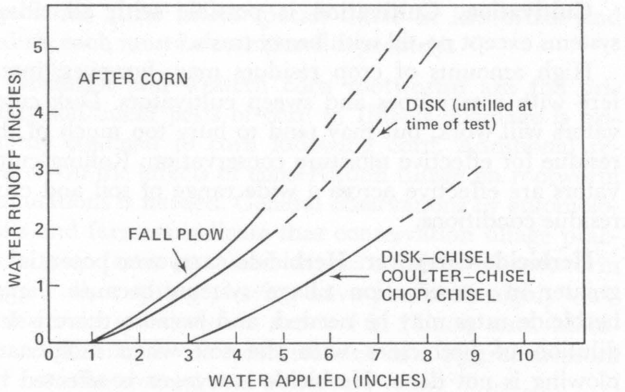
Of the first 4 inches of water applied before spring tillage after corn in the simulated rainfall tests at Urbana, the runoff was 2 inches from fall-plowed soil, 1.5 inches from untilled soil, and less than 0.25 inch from chisel-plowed soil (Figure 18). Differences in runoff after planting were not as great because the soil surface was smoothed by secondary tillage and planting operations.



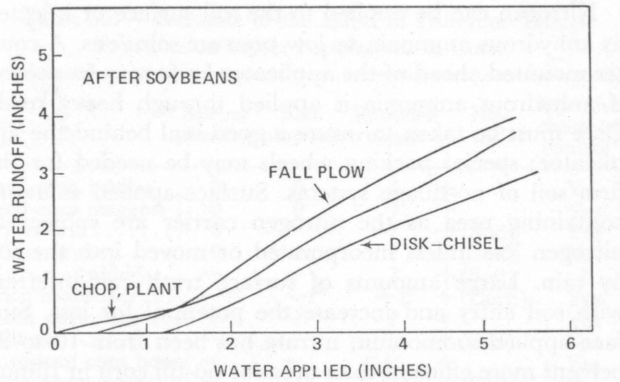
Soil loss following corn and before spring tillage (1974). (Fig. 16)



Soil loss following soybeans and before spring tillage (1974). (Fig. 17)



Water runoff for tillage treatments after corn. (Fig. 18)



Water runoff for tillage treatments after soybeans. (Fig. 19)

Runoff after soybeans was much higher than after corn, and there were only slight differences between treatments (Figure 19). Thus, runoff after soybeans is very difficult to control with common tillage systems.

Only small amounts of nitrogen and phosphorus were lost in runoff water with any of the tillage systems. Measurements of total nitrogen and total phosphorus losses correlated directly with soil losses. Thus, most nutrient losses will be controlled if soil erosion is controlled.

Crop Production With Conservation Tillage

Crop germination, emergence, and growth are largely regulated by soil temperature, moisture content, and nutrient placement. Tillage practices influence each of these components of the soil environment. Conservation tillage systems differ from conventional clean tillage in several respects.

Soil temperature. Crop residue on the soil surface insulates the soil from the sun's energy. Higher soil temperatures than normal are desired for early plant growth. Later in the season, cooler temperatures than normal are desired, but complete crop canopy at that time restricts any influence crop residue might have on soil temperature.

Minimum soil temperatures occur between 6 and 8 a.m. Tillage or crop residue has little effect on minimum soil temperature. Maximum soil temperatures at a depth of 4 inches occur between 3 and 5 p.m. During May, fields tilled by the fall-plow method have soil temperatures 3° to 5° F. warmer than those with a mulch of cornstalks.

The main effect of tillage on soil temperature occurs from late April until the crop forms a canopy that shades the soil surface. During May and early June, the lower soil temperatures caused by a mulch are accompanied by slower growth of corn and soybeans. The growth differences are greatest in years with above-normal rainfall. In dry years, there is little difference in early growth. Whether the lower soil temperature and subsequent slower early growth result in reduced yields depends largely on weather conditions during the summer, particularly during tasseling and silking. Slower growth may delay this process until weather conditions are better, but best yields normally occur when corn tassels and silks early.

Soil moisture. Surface mulch reduces evaporation. Wetter soil is an advantage in dry summer periods, but a disadvantage at planting time and during early growth on soils with poor internal drainage.

Stand establishment. Good contact between the seed and moist soil, uniform planting depth, and enough loose soil to cover the seed are necessary to produce uniform stands. Shallower than normal planting in the cool, moist soil common to many conservation tillage seedbeds may partially offset the disadvantage of lower temperatures, providing that a uniform depth is maintained and seeds are covered. Check planter adjustments frequently.

Planters must be equipped to handle the large amounts of crop residue and firm soil in no-till and some other conservation tillage seedbeds. A coulter, sweep, chisel, or other narrow tillage device must be mounted ahead of the planter unit to handle residue in the row area and open a slot in the soil for seed placement. Extra weight on the planter may be necessary to penetrate firm, undisturbed soil.

Fertilizer placement. Phosphorus and potassium fertilizers and limestone are not mobile in the soil; they remain at or near the soil surface unless they are moved by a tillage operation. This movement is least with a no-till system and greatest when soils are moldboard plowed. Research has shown that surface-applied fertilizers remain in the upper 2 inches of soil with no-till; in the upper 3 to 4 inches with chisel plow or disk tillage; and are uniformly distributed throughout the plowed layer when the tillage system includes moldboard plowing. Roots can use nutrients placed close to the surface with conservation tillage because the crop residue mulch tends to keep soil moist. Experiments in Illinois indicate that nonuniform distribution of fertility with conservation tillage does not reduce yields and should not be a major concern in deciding to adopt a conservation tillage system.

Nitrogen can be applied to the soil surface or injected as anhydrous ammonia or low pressure solutions. A coulter mounted ahead of the applicator knife may be needed if anhydrous ammonia is applied through heavy trash. Care must be taken to insure a good seal behind the applicator; special packing wheels may be needed for the firm soil of no-tillage systems. Surface-applied solutions containing urea as the nitrogen carrier are subject to nitrogen loss unless incorporated or moved into the soil by rain. Large amounts of surface trash can interfere with soil entry and increase the potential for loss. Surface-applied ammonium nitrate has been from 10 to 20 percent more efficient than urea for no-till corn in Illinois experiments.

Research indicates that from 10 to 20 percent more nitrogen may be required for no-till than for conventional tillage. This need may result from a reduced rate of nitrogen release from organic matter caused by the lower soil temperature, and from an increased potential for denitrification losses caused by the wetter soils.

Weed Control

Weed control is essential for profitable crop production with any tillage system. Cloddy soil surfaces and crop residues left by some tillage systems interfere with herbicide distribution and incorporation. Herbicide rates must not be skimpy, especially with conservation tillage. (Consult the *Illinois Field Crops Weed Control Guide,* page 62, for specific herbicide recommendations.)

Problem weeds. Perennial weeds such as milkweed and hemp dogbane may be a greater problem with conservation tillage systems. Current programs for control of weeds such as johnsongrass and yellow nutsedge call for high rates of preplant herbicides that should be thoroughly incorporated. Wild cane is another weed that is best controlled by preplant, incorporated herbicides. Volunteer corn is often a problem with tillage systems that leave the corn relatively shallow. Surface germinating weeds, such as fall panicum and crabgrass, may also increase with reduced tillage systems unless control programs are monitored closely.

Herbicide application. Surface-applied and incorporated herbicides will not give optimal performance under tillage systems that leave large amounts of crop residue and clods on the soil surface. These problems interfere with herbicide distribution and thorough herbicide incorporation.

Herbicide incorporation is impossible in no-till systems. Residual herbicides must be effective since mechanical cultivation is usually impossible. Residual herbicide rates may need to be higher under no-till and reduced tillage systems because of herbicide tie-up on crop residues. Increasing the volume of spray per acre in heavy vegetation or residues may improve control. Up to 60 gallons of water per acre may be needed for no-till in dense sod.

Cultivation. Cultivation is possible with all tillage systems except no-till with heavy trash.

High amounts of crop residues may, however, interfere with rotary hoes and sweep cultivators. Disk cultivators will work, but may tend to bury too much of the residue for effective moisture conservation. Rolling cultivators are effective across a wide range of soil and crop residue conditions.

Herbicide carryover. Herbicide carryover potential is greater in conservation tillage systems because higher herbicide rates may be needed, and because there is less dilution of herbicides with the soil when moldboard plowing is not done. Herbicide carryover is affected by climatic factors and soil conditions. Warm, wet weather and soils lead to faster breakdown than do cool, dry conditions. Soils with a pH above 7.4 tend to have greater atrazine carryover problems than those with pH values from 6.0 to 7.3.

The carryover problem can be reduced by using less of the more persistent herbicides in combination with other herbicides, or by using less persistent herbicides. Early application of herbicides reduces the potential for herbicide carryover.

Carryover can be detected by growing a sensitive species (bioassay) in soil samples from suspected fields to detect harmful levels of persistent herbicides. Carryover is not a problem if the same crop or a tolerant species is to be grown the next cropping season.

No-till weed control. Existing weed growth is destroyed before planting in conventional and in most conservation tillage systems. No-till systems require a knockdown herbicide like Paraquat or Roundup to control existing vegetation. This vegetation may be a grass or legume sod, or early germinating annual and perennial weeds. Alfalfa, marestail, and certain perennial broadleaf weeds will not be controlled by Paraquat. It may be necessary to treat these with Banvell or 2,4-D either before Paraquat application or after regrowth. Do not apply these translocated herbicides with Paraquat since the contact action to the foliage may prevent translocation.

Insect Control

Insects should not limit the adoption of conservation tillage systems. Most soil insect problems in corn that might be magnified by conservation tillage practices can be controlled with soil insecticides applied at planting. Outbreaks of above ground foliage-feeding pests can be controlled with properly timed sprays. Close monitoring of fields with insect outbreaks is very important.

Insect populations are greatly affected by soil texture, chemical composition, moisture content, temperature, and organisms in soils. Tillage operations affect some of these soil conditions and change the environment in which the insects must survive. Some tillage operations favor specific pests while others tend to reduce pest problems. Since insect species differ in life cycles and habits, each must be considered separately.

Northern and western corn rootworms are the primary soil insect pests of corn in Illinois. Damage is primarily confined to corn following corn. Additional research on the effects of conservation tillage on rootworm populations is needed. General observations by entomologists and farmers indicate that conservation tillage practices may favor increased winter survival of rootworm eggs. Fall or spring plowing have produced highly variable results on rootworm survival in Illinois tests. Moldboard plowing is not recommended as a control measure for corn rootworms.

European corn borer larvae overwinter in corn stalk residues. Tillage systems that leave corn stalks on the surface could result in increased populations of first-generation moths and subsequent damage by the first brood in late June or early July.

Black cutworm outbreaks in corn appear more frequently with conservation tillage systems than in conventionally tilled fields, probably because cutworm moths deposit eggs on vegetation or surface debris. Recent research by the Illinois Natural History Survey suggests that egg-laying occurs prior to planting. Chickweed and other winter annual weeds not buried by tillage serve as hosts for egg-laying and cutworm survival. These preliminary observations indicate that both weediness and tillage practices contribute to cutworm problems.

No-Till Pest Problems

Insect problems occur more frequently in no-till corn than in other conservation tillage systems, and are often more serious. No-till gives pests a stable environment for survival and development. Soil insecticides can be profitably applied to corn following grass sod or in any rotation where grass and weeds are prevalent. It does not generally pay to apply a soil insecticide to no-till corn following corn (except in rootworm infested areas), soybeans, or a small grain. A diazinon planter-box seed treatment should, however, be used to protect against damage by seed-corn beetles and seed-corn maggots.

Table 55 provides information on the effects of tillage practices on pest problems in corn, based on estimates of extension entomologists.

Table 55. — Estimate of the Effect of Different Tillage Practices on Insect Populations in Corn[a]

Pest	Spring plowing	Fall plowing	Reduced tillage	No-till[b]	Effective chemical control[c]
Seed-corn beetles	0	0	?	+	Yes
Seed-corn maggots	0	0	?	+	Yes
Wireworm	0	—	?	+ (Sod)	Yes
White grubs	0	—	?	+ (Sod)	No
Corn-root aphids	—	—	?	+ (Sod)	?
Corn rootworm	— ?[d]	— ?[d]	+ ?[d]	+ (Corn)	Yes
Black cutworms	?	?	?	+	Yes
Billbugs	—	—	—	+ (Sod)	Yes
European corn borer	—	—	+	+	Yes
True armyworms	—	—	—	+ (Sod)	Yes
Common stalk borer	—	—	—	+	No
Slugs	—	—	—	+	No
Mice	—	—	—	+ (Sod)	Yes

[a] + = the practice will increase the populations or potential for damage by the pest.
— = it will reduce the population or potential for damage.
0 = no effect on the pest.
? = effect unknown on the pest.

[b] The preceding crop will have a direct influence on the pest problem(s) in no-till corn.

[c] More specific information on insect pest management is presented in the current *Insect Pest Management Guide — Field and Forage Crops.* This circular is revised annually; only the latest edition should be used.

[d] Results, based on general observation, are tentative.

Disease control. The potential for plant disease is greater when mulch is present than it is when fields are clear of residue. With clean tillage, residue from the previous crop is buried or otherwise removed. Since buried residue is subject to rapid decomposition, infected residue is likely to be removed through decay.

Volunteer corn is likely to be a problem unless the soil is moldboard-plowed in the fall or the zero-till system is used. If the volunteer corn is a disease-susceptible hybrid, the possibility for early infection with diseases such as southern corn leaf blight increases.

Although the potential for plant disease is greater with mulch tillage than with clean tillage, the erosion control benefit of mulch tillage is great. This benefit needs to be balanced against the increased potential for disease. Disease-resistant hybrids and varieties can be used to reduce problems of plant disease. Crop rotation or modification of the tillage practice may be justified if a disease problem appears likely.

Crop Yields

Conservation tillage systems have produced yields comparable to those from conventional tillage on most Illinois soils when stands are adequate and pests are controlled. Yields on poorly drained fine-textured soils (silty clay loam, silty clay, and clay) have been consistently higher when soils are moldboard-plowed after corn. Soils with root-restricting claypan or fragipan subsoils, on the other hand, have frequently produced higher corn yields where moisture conserving conservation tillage is used (Table 56).

Symerton silt loam is a dark prairie soil with good internal drainage that is free of root restricting layers in the upper 40 to 48 inches. Yields with chisel plow and conventional systems have been nearly identical. No-till corn yields are lower due to inadequate weed control.

Drummer silty clay loam is a dark, heavy, poorly drained prairie soil that is sticky and compacts easily if tilled when wet. A cornstalk mulch with chisel, disk, or zero-tillage results in slow early growth and lower yields. Corn yields with chisel and spring disk systems are similar to yields with conventional tillage following soybeans.

Cisne silt loam is a poorly drained claypan soil that is common in south-central Illinois. The claypan subsoil restricts root development and water use by the crop. Reduced evaporation with the cornstalk mulch of chisel and zero-till systems conserves water for crop use, frequently resulting in higher yields than with clean tillage.

Grantsburg silt loam is a light-colored, sloping soil that is common in southern Illinois. A dense hardpan or fragipan in the subsoil restricts root development. The residue mulch with conservation tillage frequently produces higher yields as a result of moisture conservation.

Production Costs

Will the switch from a conventional moldboard plow system to a conservation tillage system be profitable? The answer depends on how one weighs the importance of three primary factors: yield, cost, and erosion control. The relation of yield to the tillage system used has been discussed in the preceding section.

One of the major production costs affected by the choice of tillage system is machinery investment. If you do not already have tillage equipment on hand and have to purchase new machinery, the capital investment and the depreciation and interest costs of the equipment needed for conservation tillage will be somewhat less than for conventional tillage because the implements and power units can be smaller. Of course, if conservation tillage is used on only a part of the land farmed, larger equipment would be needed for the other portion, and thus there would be no savings.

With a conservation tillage system, there will be some reduction in labor because there are no fall or spring tillage operations. The labor saved in this way has value only if it reduces hired labor costs or if the saved unpaid labor is directed into other productive activities such as raising livestock, farming more acres, or reducing machinery costs by substituting smaller machines.

One cost increase sometimes associated with a conservation tillage system is the cost of additional or more expensive pesticides and fertilizers (for example, contact herbicides are needed with no-tillage systems).

Table 56. — Corn Yields with Plow, Chisel, and No-Tillage Systems

Tillage system	Well drained Symerton silt loam[a]	Poorly drained Drummer silty clay loam[b]	Claypan Cisne silt loam[c]	Fragipan Grantsburg silt loam[d]
	Bushels per acre			
Moldboard plow . .	112	165	87	112
Chisel plow	110	159	114	
No-till	99	144	108	115

[a] Elwood, 1972-75.
[b] Urbana, 1974-77.
[c] Brownstown, 1974-77.
[d] Dixon Springs, 1967-76.

These increases must be weighed against the reduced fuel and machinery repair costs involved in performing fewer operations. The resulting total cost shows no clear advantage for any reasonable tillage system as long as equivalent yields are obtained.

On many farms it may not be feasible or necessary to switch completely from the conventional moldboard plow system to a single conservation tillage system. Table 57 shows the results of using a combination of a moldboard system on flat ground and a no-till system on sloping land. Adopting a no-till system on those acres where erosion control is necessary would increase fixed machinery, pesticide, and fertilizer costs for the entire farm but would also reduce repair, fuel, and labor costs.

The major advantage of reduced tillage is improved erosion control. With an appropriate soil conservation practice such as contouring, soil losses can reach the tolerance level under alternative systems or rotations. Therefore, if the objective is to meet that level, a conservation tillage system such as no-till would cost less on grain farms than an alternate method such as a less intensive rotation of corn, soybeans, oats, and meadow.

Table 57. — Estimated Production Costs and Soil Losses with Different Tillage Systems, Crop Rotations, and Conservation Practices

Tilltage systems and rotations	Machinery depreciation and interest	Machinery repair and fuel	Pesticide	Fertilizer	Direct labor	Soil loss[a]: 2 percent slope, no conservation practice	Soil loss[a]: 5 percent slope, no conservation practice	Soil loss[a]: 5 percent slope, contoured
	Dollars per acre	*Dollars per acre*	*Dollars per acre*	*Dollars per acre*	*Hours per acre*	*Tons per acre*	*Tons per acre*	*Tons per acre*
CORN-SOYBEAN ROTATION								
Moldboard and chisel	43	26	14	42	1.9	6.4	25.1	12.6
Chisel	43	24	16	42	1.7	4.5	17.1	8.6
Tandem disk	40	19	17	42	1.4	3.8	14.5	7.3
No-till	36	14	28	46	1.0	.9	3.4	1.7
Combination: moldboard on flat ground, no-till on sloping land . . .	44	22	21	44	1.6	6.4[b]	3.4[c]	1.7[c]
CORN-SOYBEAN-OATS-MEADOW ROTATION								
Moldboard	38	14	8	20	1.4	2.5	9.6	4.8

[a] Calculated for Flanagan and Catlin soil types using formulas and data from R. D. Walker and R. A. Pope, *Estimating Your Soil Erosion Losses with the Universal Soil Loss Equation (USLE)*.
[b] Only moldboard used.
[c] Only no-till used.

IRRIGATION

Since Illinois receives an average of 36 inches of precipitation annually and has a potential moisture loss through evapotranspiration (E.T.) of only 30 inches, need we be interested in irrigation? Even though there is a year now and then when rainfall is below normal, do these occur frequently enough to justify the expense of buying irrigation equipment, or of developing a water source, and of applying the water? The answer is *yes* for a growing number of farmers in Illinois.

While it is true that every section of Illinois normally receives more water as rain and snow each year than is lost by E.T., at some time during the growing season soil moisture is not sufficient for optimum crop growth.

At least 20 inches of water are needed to produce a good crop of corn or soybeans in Illinois with current cultural practices. All sections of the state average at least 15 inches of rain from May through August. Thus at least 5 inches of stored subsoil moisture are needed in a normal year to produce satisfactory yields.

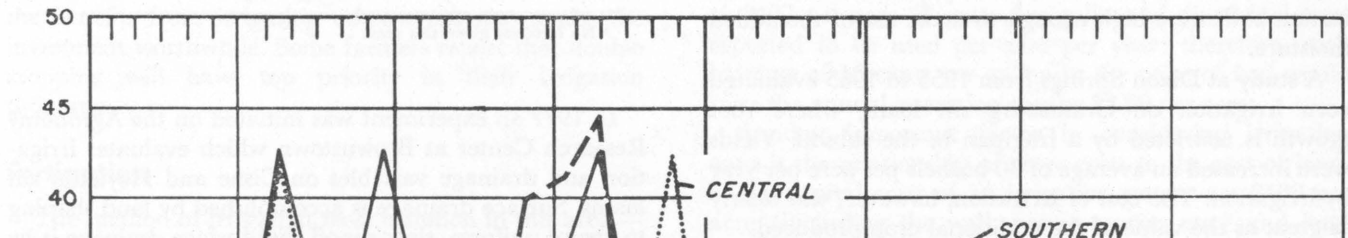
Crops growing on deep soil with high water-holding capacity (fine-textured soil with high organic matter content) may get by quite well if precipitation is not appreciably below normal and if the soil is filled with moisture at the beginning of the season.

Sandy soils and soils with subsoil layers that restrict water movement and root growth are not able to store as much as five inches of available moisture. Crops on these soils suffer from inadequate moisture every year. Most of the other soils in the state can hold more than five inches of available moisture in the top five feet. Crops on these soils may suffer from moisture deficiency when subsoil moisture is not fully recharged by about May 1 or when summer precipitation is appreciably below normal or poorly distributed through the season.

The probability of getting 1 inch or more of rain in any week is shown in Figure 20. One inch of rain per week will not replace E.T. losses during the summer, but it is sufficient to keep lack of moisture from severely limiting crop growth on soils with reasonably good moisture-holding capacity.

This probability is lowest in all sections of Illinois during the last half of July, when corn normally is pollinating and soybeans are flowering.

Moisture stress delays the emergence of corn silks and shortens the period of pollen shedding, thus reducing the time of overlap between the two processes. The result is incomplete kernel formation, which can have disastrous effects on corn yields.



Chance of one inch or more rain in one week. (Fig. 20)

Data from Iowa State University indicate that corn yields may be reduced as much as 40 percent when four consecutive days of visible wilting are encountered at the time of silk emergence. Their studies have also shown similar yield reductions in soybeans from severe drought during the pod-filling stage.

An increasing number of farmers are installing irrigation systems to prevent the detrimental effects of moisture deficiency. Some years of below-normal summer rainfall and other years of erratic rainfall distribution through the season have been at least partially responsible for the increase. Current high costs of production and some periods of high commodity prices have given added importance to the need for stabilizing yields at high levels. As other yield-limiting factors are eliminated, adequate moisture to assure top yields becomes increasingly important. Most of the irrigation development has been on sandy soils or other soils with correspondingly low levels of available water. Some installations have been made on deeper, fine-textured soils and other farmers are considering irrigation of such soils.

Irrigation and Yields

Research in the North Central states from 1950 through 1958 indicated that irrigation increased corn yields by 30 bushels per acre on loams and by nearly 60 bushels on sands. In those experiments, plant population and fertilization both were high enough to make use of the added moisture.

A study at Dixon Springs from 1955 to 1965 evaluated corn irrigation on Grantsburg silt loam, where root growth is restricted by a fragipan in the subsoil. Yields were increased an average of 30 bushels per acre per year by irrigation. The cost of irrigation, however, was nearly as great as the value of the additional crop produced.

In 1974 irrigation research of corn and soybeans was initiated on Plainfield sand at the Illinois River Valley Sand Field in Mason County. From 1974 to 1976, three frequencies of irrigation were studied: daily, twice a week, and once a week. Total amount of water per week was constant and was equivalent to about ¼ inch per day. In 1974 corn yields of 180 bushels per acre and soybean yields of 58 bushels per acre were obtained. Nonirrigated yields were not taken in 1974. Corn yields slightly higher than 200 bushels per acre were obtained in 1975 and 1976 with irrigation and with high fertility treatments. Unirrigated corn yielded 70 to 80 bushels per acre with the same fertility treatments. Irrigated corn with no fertilizer added yielded less than 30 bushels per acre on this sandy soil. Full season soybeans yielded 55 and 45 bushels per acre in 1975 and 1976. The yields from nonirrigated soybean plots in those years were 30 and 16 bushels, respectively.

In 1979 yield comparisons were made for a limited number of corn hybrids and soybean varieties that had been placed under one irrigation regime. The highest yields measured were 168 bushels for corn and 62 bushels for soybeans.

From 1974 through 1978 an experiment on the Sand Field tested the effects of fertilization on irrigated corn plots. Some plots received no fertilizer, some received a 120-60-60 fertilizer, some a 300-150-150 fertilizer, some sludge, and some manure (Table 58). The sludge was applied in amounts sufficient to supply approximately 300 pounds of nitrogen per acre per year. The sludge also supplied adequate phosphorus; however, potash supplements were necessary. The manure supplied about 200 pounds of nitrogen per acre per year. In 1979 the same plots were planted with soybeans without any additional treatment; Table 58 gives yields for both crops. The significantly lower figures for the plots with no fertilizer treatment indicate that adequate fertilization and irrigation are both essential to high yield production.

Table 58. — Corn and Soybean Yields on Fertilized and Unfertilized Irrigated Sand Field Plots

Treatment given 1974–1978	Corn yield 1974–1978	Soybean yield 1979[a]
	Bushels per acre	
No fertilizer	32	58
120-60-60 fertilizer	120	68
300-150-150 fertilizer	184	67
Sludge and potash	179	75
Manure	139	63

[a] No fertilizer given this year.

In 1977 an experiment was initiated on the Agronomy Research Center at Brownstown which evaluates irrigation and drainage variables on Cisne and Hoyleton silt loams. Surface drainage is accomplished by land shaping to assure uniform, slow runoff. Subsurface drainage is by 3-inch diameter perforated plastic drain tubes installed on 20-foot spacings. The tubes are placed at a shallow depth — just above the clay pan layer. Surface irrigation water is distributed through gated pipe and runs down furrows between the rows. Sprinkler irrigation is by a solid-set system with a low application rate. The water source is a pond constructed on the farm and the plots are in the watershed of the pond. Runoff water, whether from rain or from irrigation, accumulates in the pond.

In 1978 drainage had little effect on corn yields, whereas irrigation increased yields from 53 bushels per acre to 150 bushels per acre. In 1979, however, drainage treatments influenced corn yields more than did irrigation. In this year, water standing for a number of days on the surface of undrained plots reduced yields to only 23 bushels per acre. Plots with subsurface drainage, on the other hand, yielded 160 bushels per acre without irrigation and 195 bushels per acre with irrigation.

In 1979 an irrigation experiment was begun at Norris Mine in Fulton County as part of a comprehensive research program for reclaiming strip-mined land. The water source is a terminal pond formed by the mining operation. Corn grown on unirrigated mine spoil yielded

100 bushels per acre, and corn grown on unirrigated mine spoil with 18 inches of topsoil added yielded 155 bushels per acre. In each case, irrigation increased yields by about 40 bushels per acre. Soybeans grown on mine spoil with topsoil added yielded 21 bushels per acre without irrigation and 40 bushels per acre with irrigation.

Irrigation for Double Cropping

Proper irrigation can eliminate the most serious problem in double cropping: inadequate moisture to get the second crop off to a good start. No part of Illinois has better than a 30-percent chance of getting an inch or more of rain during any week in July and most weeks of August. If one has irrigation equipment, double-crop irrigation should receive high priority in the operational program. If one is not irrigating but is considering it, the possibility of double cropping under irrigation should be taken into account in making the decision. Soybeans planted at Urbana July 6 following wheat harvest have yielded as much as 38 bushels per acre with irrigation.

In Mason County, soybeans planted the first week in July have yielded as much as 30 bushels per acre with irrigation.

While it may be difficult to justify investing in an irrigation system for double-crop soybeans alone, the potential benefits from irrigating double-crop beans added to the benefits from irrigating other crops may make the investment worthwhile. Some farmers report that double cropping will have top priority in their irrigation programs.

Fertigation

The method of irrigation most common in this area — overhead sprinkler — is the one best adapted to applying fertilizer along with water. Fertigation permits nutrients to be applied to the crop as they are needed. Several applications can be made during the growing season with little if any additional cost of application. Nitrogen can be applied during periods when the crop has a heavy demand for both nitrogen and water. Corn uses nitrogen and water most rapidly during the three weeks before tasseling. About 60 percent of the nitrogen needs of corn must be met by silking time. Generally, it is recommended that nearly all the nitrogen for the crop should be applied by the time it is pollinating, even though appreciable uptake occurs after this time. Fertilization through irrigation can be a convenient and timely method of supplying part of the plant's nutrient needs.

In Illinois, fertigation appears to be best adapted to sandy areas where irrigation is likely to be needed even in wettest years. On finer-textured soils with high water-holding capacity, one may be faced with need for nitrogen but with no lack of moisture. Neither irrigating just to supply nitrogen nor allowing the crop to suffer for lack of nitrogen is an attractive alternative. Even on sandy soils, only part of the nitrogen should be applied with irrigation water, with preplant and sidedress applications providing the rest of it.

Other problems associated with fertigation can only be mentioned here. These include (1) possible lack of uniformity of application, (2) loss of ammonium nitrogen by volatilization in sprinkling, (3) loss of nitrogen and resultant ground-water contamination by leaching if overirrigation occurs, (4) corrosion of equipment, and (5) incompatibility of some fertilizer materials and low solubility of some. Good discussions of these and factors affecting them can be found in textbooks, scientific journals, farm periodicals, and trade journals.

Cost and Return

In 1979 the cost of irrigating field corn with a center-pivot system in Mason County was about $96 an acre per year: $77 an acre per year for equipment and $19 an acre per year for operating expenses. Further costs associated with obtaining a yield large enough to offset the cost of irrigation were found to be about $23 an acre per year, giving a total cost associated with irrigation of $119 an acre per year. These data came from a study of irrigated farms by Dorrence Brucker, FBFM Fieldman in Mason County. The total investment for the irrigation system, including pivot, pump and gear head, diesel engine, and a 100-foot-deep well, amounted to $407 per acre. Twenty-five gallons of diesel fuel were reported to be used per acre per year; therefore, each increase of 10 cents per gallon in the price of fuel would raise the annual operating cost by $2.50 per acre.

Another important factor in considering irrigation costs is the relationship of these costs to the cost of land. If the capital costs of an irrigation system are $400 per acre (including the well, power source, etc.) and land costs $2,000 per acre, the irrigation equipment cost is 16.7 percent of the total. If the land cost is $4,000 per acre, the same $400 cost for irrigation equipment becomes 9.1 percent of the total. Irrigating existing acreage now under cultivation will help stabilize production from year to year. Many farmers are weighing this alternative against the purchasing or leasing of additional land. One farmer reports that he added irrigation for 160 acres at the same cost as that of purchasing an additional 20 acres.

If the annual cost of irrigation is $119 per acre, a 34-bushel-per-acre increase in corn yield would pay the added cost if the price were $3.50 per bushel. With a high level of management, yield increases of nearly twice this amount might be expected on sandy soils during most years in Illinois.

With a soybean price of $7.40 per bushel, a yield increase for irrigation of 16 bushels per acre would be needed to recover costs. Yield increases were approximately double these amounts in 1974 and 1975 in Mason County experiments. Good evaluations of soybean irrigation on finer-textured soils in Illinois are not available as yet.

The Decision To Irrigate

If a producer is convinced that it will be profitable for him to install an irrigation system, he must have an adequate source of water. Such sources do not exist at present in many parts of the state. We are fortunate in that underground water resources are generally good in the sandy areas where irrigation is most likely to be needed. A relatively shallow well in some of these areas may provide enough water to irrigate a quarter section of land. In some areas of Illinois, particularly the northern third, deeper wells may provide a relatively adequate source of water for irrigation.

Many farmers are pumping their water from streams for irrigation. This can be a relatively good and low-cost source; but, of course, the stream may dry up in a drought year. Impounding surface water on an individual farm is possible in many areas of the state, and some farmers are doing that. However, an appreciable loss may occur both from evaporation and from seepage into the substrata. The rule-of-thumb figure is that you probably need to store 2 acre-inches of water for each acre-inch actually applied to the land. Although in many areas the water-development costs are likely to be beyond the range of feasibility for an individual farmer, such development by groups of farmers, cooperatives, or governmental agencies could produce a sufficient water supply in one containment for a number of irrigators.

27,000 gallons of water are required to make a one-inch application on one acre (one acre-inch). A flow of 450 gallons per minute will give one acre-inch per hour. Thus a 130-acre center pivot system with a flow of 900 gallons per minute can apply 1 inch of water over the entire field in 65 hours of operation. Since some of the water is lost to evaporation and some may be lost from deep percolation or runoff, the net amount added will be less than ½ inch.

The Illinois State Water Survey and the Illinois State Geological Survey at Urbana can provide information on the availability of water for irrigation. Submit a legal description of the site on which you plan to develop a well and request information regarding its suitability for irrigation-well development.

At present, no permit is required in Illinois to use water for irrigation. The Riparian Doctrine, which governs the use of surface waters, states that a person is entitled to a reasonable use of the water which flows over or adjacent to his or her land, as long as that person does not interfere with someone else's right to use the water. No problem results as long as there is plenty of water for everybody. But when the amount of water becomes limiting, legal determinations may have to be made as to whether one's use interferes with someone else's rights concerning the water. It may be important to have a legal record established in order to verify the date on which the use of water for irrigation began.

Assuming you believe that it will be profitable for you to irrigate and that you have an assured supply of water, how do you find out what type of equipment is available and what will be best for your situation? University representatives have discussed this question in various meetings around the state; but they cannot, of course, design a system for each individual farm. Your county extension adviser can provide you with a list of dealers located in Illinois and others who serve Illinois. This list gives the kinds of equipment each dealer sells, but will not give you information about the characteristics of those systems.

We suggest that you contact as many dealers as you wish and discuss your needs with them in relation to the type of equipment they sell. You will then be in a much better position to determine what equipment to purchase.

Irrigation Scheduling

Experienced irrigators have developed their own procedures for scheduling applications, whereas beginners may have to determine timing and rates of application before they feel prepared to do so. Irrigators generally follow one of two basic methods of scheduling, each of which has numerous variations. The first method involves measuring soil moisture and plant stress by 1) taking soil samples at various depths with a soil probe, auger, or shovel and then measuring or estimating the amount of moisture available to the plant roots; or 2) inserting instruments such as tensiometers or electrical resistance blocks into the soil to desired depths and then taking readings at intervals; or 3) measuring or observing some plant characteristic and then relating this characteristic to moisture stress. The other method of scheduling, frequently called the "checkbook method," involves keeping a balance of the amount of moisture in the soil by measuring the amount of rainfall and then measuring or estimating the amount of moisture lost from crop use and evaporation. When the moisture level drops to a certain level, the field is irrigated. Computer techniques are also available for estimating moisture loss, computing the moisture balance, and predicting when irrigation is necessary.

Management Requirements

Irrigation will provide maximum benefit only when it is an integral part of a high-level management program. Good seed or plant starts of proper genetic origin planted at the proper time and at a sufficiently high plant population, accompanied by optimum fertilization, good pest control, and other recommended cultural practices, is necessary to assure the highest benefit from irrigation.

Farmers who invest in irrigation may become disappointed if they do not manage the irrigation properly. They often overextend their systems so much that they cannot maintain adequate soil moisture when the crop requires it. For example, the system may be designed to apply 2 inches of water to 100 acres once a week. In 2 or more successive weeks, soil moisture may be limiting, with potential evapotranspiration equaling 2 inches per week. If the system is used on one 100-acre field one week and another field the next week, neither field may receive much benefit, especially if moisture stress comes at a critical time, such as during pollination. Inadequate production of marketable products may result.

Currently we suggest that irrigators follow the cultural practices they would use to obtain the most profitable yield in a year of ideal rainfall. In many parts of the state 1975 was such a year. Other years have been nearly ideal in some sections of Illinois. If a farmer's yield is not already appreciably above the county average for that farmer's soil type, he or she needs to improve management of other cultural factors before investing in an irrigation system.

The availability of irrigation on the farm permits the use of optimum production practices every year. If rains should come as needed, the investment in irrigation equipment would not have been needed that year, but no operating costs would have been involved. If rainfall should be inadequate, however, the yield potential would still be realized every year.

Illinois Irrigation Newsletter

The University of Illinois College of Agriculture issues the *Illinois Irrigation Newsletter,* which covers items of particular concern to irrigators. A modest subscription charge covers cost of printing and mailing. Subscription forms may be obtained from county Cooperative Extension Service offices or by writing to the Agricultural Newsletter Service, Cooperative Extension Service, 116N Mumford Hall, Urbana, Illinois 61801.

1981
FIELD CROPS WEED CONTROL GUIDE

This guide is based on the results of research conducted by the University of Illinois Agricultural Experiment Station, other experiment stations, and the U.S. Department of Agriculture. Consideration has been given to the soils, crops, and weed problems of Illinois.

Rainfall, soil type, method of application, and formulation influence herbicide effectiveness. Under certain conditions some herbicides may damage crops to which they are applied. In some cases, herbicide residues in the soil may damage crops grown later.

When selecting a herbicide, consider both the risk involved in using the herbicide and the yield losses caused by weeds. If cultivation and good cultural practices are controlling weeds, herbicides may be unnecessary. You can reduce risks by taking these precautions:

- Apply herbicides only to those crops for which use has been approved.
- Use recommended rates. Applying too much herbicide is costly and in addition may damage crops and cause illegal residues. Using too little herbicide can result in poor weed control.
- Apply herbicides only at times specified on the label. Observe the recommended intervals between treatment and pasturing or harvesting of crops.
- Wear goggles, rubber gloves, and other protective clothing as suggested by the label.
- Guard against possible injury to nearby susceptible plants, such as soybeans, grapes, and tomatoes. Mist or vapors from 2,4-D, MCPA, and dicamba sprays may drift several hundred yards. To reduce the chance of damage, calibrate and operate sprayers at low pressure with tips that deliver large droplets and high gallonage output. Spray only on calm days or make sure air is not moving toward susceptible crop plants and ornamentals.
- Apply herbicides only when all animals and persons not directly involved in the application have been removed from the area. Avoid unnecessary exposure.
- Check label for proper method of container disposal. Triple rinse, puncture, and haul metal containers to an approved sanitary landfill. Haul paper containers to a sanitary landfill or burn them in an approved manner.
- Return unused herbicides to a safe storage place promptly. Store them in original containers, away from unauthorized persons, particularly children.
- Since manufacturers' formulations and labels are sometimes changed and government regulations modified, always refer to the most recent product label.

This guide has been developed to help you use herbicides as effectively and safely as possible. However, since no guide can remove all the risk involved, the University of Illinois and its employees assume no responsibility for results of using herbicides, even if they have been used according to the suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Cultural and Mechanical Control

Most weed control programs combine good cultural practices, mechanical weed control, and herbicide applications. Good cultural practices to aid weed control include preparation of a good seedbed, adequate fertilization, crop rotation, seeding on the proper date, use of the optimum row width, and seeding at the rate for optimum stands.

Planting in relatively warm soils helps crops compete better with weeds. Good weed control during the first 3 to 5 weeks is extremely important for both corn and soybeans. If weed control is adequate during that period, corn and soybeans will usually compete quite well with most of the weeds that begin growth later.

Narrow rows will shade the centers faster and help the crop compete better with the weeds. However, if herbicides alone cannot give adequate weed control, then keep rows wide enough to allow cultivation. Some of the newer herbicides are improving the chances of adequate control without cultivation.

Use the rotary hoe after weed seeds have germinated but before most have emerged. Operate the rotary hoe at 8 to 12 miles per hour and weight it enough to stir the soil and kill the tiny weeds. Rotary hoeing also aids crop emergence if the soil is crusted.

If a preemergence or preplant herbicide does not appear to be controlling weeds adequately, use the rotary hoe while weeds are still small enough to be controlled.

Row cultivators also should be used while weeds are small. Throwing soil into the row can help smother small weeds, but be careful not to cover the crop. If a banded herbicide has given adequate weed control in the row, use shields to prevent soil movement into the row during the first cultivation. Cultivate shallow to prevent injury to crop roots. Avoid excessive ridging; it may hinder harvesting and encourage erosion.

Herbicides can provide a convenient and economical means of early weed control by allowing delayed and faster cultivation. Furthermore, unless the soil is crusted, it is usually not necessary to cultivate at all when herbicides are controlling weeds adequately.

Conservation Tillage and Weed Control

Conservation tillage protects the soil from erosion by making the soil surface rough and by covering it with crop residue. However, it hinders weed control in several ways. For instance, clods that are not penetrated during herbicide application may "melt down," creating untreated weedy areas, or clods and crop residue may make uniform herbicide incorporation difficult or impractical.

Reduced primary tillage can also increase weed problems. It tends to leave a high number of weed seeds on or near the soil surface, allowing annual grasses such as fall panicum to become established. Furthermore, because conservation tillage systems disturb the soil and roots much less than conventional systems, perennial weeds are apt to become more of a problem.

Thus, because it increases weed pressure and causes variable herbicide distribution, reduced tillage presents a challenge to weed-control programs. To insure the success of your program, exercise greater care in choosing herbicides and application rates and try to make more accurate and timely applications. By using preemergence herbicides you can get better distribution than with incorporated treatments, although the success of the former is more dependent on rainfall. The effectiveness of postemergence herbicides in controlling grass has varied more than that of soil-applied treatments. Thus, because both preemergence and postemergence herbicides have definite advantages as well as disadvantages, simply changing the time of application may not necessarily solve your problem. Instead, you may need to use a sequence or combination of more herbicides at higher rates. In any case, do not use more than is called for in the label instructions. (See the no-till section for more information.)

Chemical Weed Control

Plan your chemical weed-control program to fit your soil, crops, weed problems, and farming operations. Herbicide performance depends on the weather and on wise selection and application. Your decisions on herbicide use should be based on the nature and seriousness of your weed problems.

Corn or soybeans occasionally may be injured by some of the herbicides registered for use on them. However, the benefits from weed control are usually much greater than the adverse effects. Crop tolerance ratings for various herbicides are given in the table on the last page of this article. Corn or soybeans under stress from soil crusting, depth of planting, or adverse weather are more subject to herbicide injury. Plants injured by a herbicide are likely to be more subject to disease.

Apply the herbicide at the time specified on the label. Select and apply herbicides at the correct rate in order to reduce crop injury. The application rates for most herbicides vary with soil texture and organic matter.

You must also consider the kinds of weeds likely to be present. The herbicide selectivity table at the end of this guide indicates the susceptibility of our most common weed species to herbicides.

Crop planting intentions for the next season must also be considered. Where high rates of atrazine are used, you should not plant soybeans, small grains, alfalfa, or vegetables the following year. If you are considering planting wheat after soybeans, be sure that the application of Treflan or similar herbicides for soybeans is uniform and sufficiently early to reduce the risk of injury to wheat or corn following soybeans. Refer to the herbicide label for cropping sequence information.

Names of Some Herbicides

Trade	Common (generic)
AAtrex, Atrazine	atrazine
Amiben	chloramben
Amino triazole, Weedazol	amitrole
Amitrol-T, Cytrol	amitrole-T
Ammate	AMS
Balan	benefin
Banvel	dicamba
Basagran	bentazon
Basalin	fluchloralin
Bicep	metolachlor + atrazine
Bladex	cyanazine
Blazer	acifluorfen
Butoxone, Butyrac	2,4-DB
Dowpon M	dalapon
Dual	metolachlor
Dyanap, Ancrack, Klean-Krop	naptalam plus dinoseb
Eradicane, Eptam	EPTC
Evik	ametryn
Furloe Chloro IPC	chlorpropham
Hoelon	dichlofop
Kerb	pronamide
Krenite	fosamine
Lasso	alachlor
Lorox	linuron
Milogard	propazine
Modown	bifenox
Paraquat	paraquat
Premerge 3	dinoseb
Princep, Simazine	simazine
Prowl	pendimethalin
Ramrod, Bexton, Propachlor	propachlor
Roundup	glyphosate
Sencor, Lexone	metribuzin
(several)	MCPA
(several)	2,4-D

Sinbar .... terbacil
Surflan .... oryzalin
Sutan+ .... butylate
Tolban .... profluralin
Tordon .... picloram
Treflan .... trifluralin
Vernam .... vernolate

Some herbicides have different formulations and concentrations under the same trade name. *No endorsement of any trade name is implied, nor is discrimination against similar products intended.*

Herbicide Rates

Herbicide rates vary according to the time of application, soil conditions, the tillage system used, and the seriousness of the weed infestation. Sometimes lower rates are specified for preemergence application than for preplant incorporated application. Postemergence rates may be lower than preemergence rates if the herbicides can be applied at either time. Postemergence rates often vary depending on the size and species of the weeds and on whether an adjuvant is specified. Rates for combinations are usually lower than for herbicides used alone.

The rates for soil-applied herbicides usually vary depending on the texture of the soil and the amount of organic matter it contains. For instance, light-colored, medium-textured soils with little organic matter require relatively lower rates of most herbicides than do the dark-colored, fine-textured soils with medium to high organic matter. For sandy soils the herbicide label may specify "do not use," "use a reduced rate," or "use a postemergence rather than soil-applied herbicide," depending on the herbicide and its adaptation and on crop tolerance.

Reduced tillage systems sometimes require higher rates than conventional systems. Higher rates are especially necessary in the case of corn stubble, since considerable crop residue remains on the soil surface.

The rates given in this publication are, unless otherwise specified, broadcast rates for the amount of formulated product. If you plan to band or direct herbicides, adjust the amount per crop acre according to the percentage of the area actually treated. Many herbicides have several formulations with different concentrations of active ingredient. Be sure to read the label and make the necessary adjustments when changing formulations.

Herbicide Combinations

Herbicides are often combined to control more weed species, reduce carryover, or reduce crop injury. Some combinations are sold as a "package mix," while others are tank mixed. Tank mixing allows you to adjust the ratio to fit local weed and soil conditions. If you use a tank mix, you must follow restrictions on all products used in the combination.

Problems sometimes occur when mixing emulsifiable concentrate (EC) formulations with wettable powder (WP), water dispersible liquid (WDL), water dispersible granule (WDG), or dry flowable (DF) formulations. These problems can sometimes be prevented by using proper mixing procedures. Fill tanks at least one-third full with water or liquid fertilizer before adding herbicides. If using liquid fertilizers, check compatibility in a small lot before mixing a tankful. The addition of compatibility agents may be necessary. Wettable powders, WDGs, DFs, or WDLs should be added to the tank before ECs. Pre-emulsify ECs by mixing with equal volumes of water before adding them to the tank. Empty and clean spray tanks often enough to prevent accumulation of material on the sides and the bottom of the tank.

Some of the herbicide combinations that have been registered are listed below. The herbicide listed first is the one that carries label or supplemental instructions on mixing. The label of the other herbicide(s) may also have mixing instructions.

Corn

Atrazine + Princep (PPI, Pre, NT/P, NT/R)[1]
Atrazine + propachlor (Pre, early Post)
Banvel + atrazine (Post)
Banvel + Lasso (Pre, early Post)
Banvel + 2,4-D (Post)
Basagran + atrazine (Post)
Bexton + Bladex (Pre)
Bladex + atrazine (Pre, PPI, NT/P)
Bladex + Paraquat (NT)
Bladex + Sutan+ (PPI)
Dual + AAtrex (PPI, Pre, early Post, NT/P, NT/R)
Dual + Princep (PPI, Pre, NT/P, NT/R)
Dual + atrazine + Princep (PPI, Pre, NT/P, NT/R)
Dual + Banvel (Pre, early Post)
Dual + Bladex (PPI, Pre)
Eradicane + atrazine (PPI)
Eradicane + Bladex (PPI)
Lasso + atrazine (PPI, Pre, early Post, NT/P, NT/R)
Lasso + Bladex (Pre, PPI, NT/R)
Lasso + Princep (NT/R)
Paraquat + atrazine (NT)
Prowl + atrazine (Pre, early Post)
Prowl + Banvel (Pre)
Prowl + Bladex (Pre, early Post)
Sutan+ + atrazine (PPI)
Sutan+ + atrazine + Bladex (PPI)

Soybeans

Amiben + Lasso (Pre)
Amiben + Lorox (Pre)
Amiben + Sencor (Pre)
Amiben + Treflan (PPI)
Basalin + Sencor or Lexone (PPI)
Dual + Amiben (PPI, Pre)
Dual + Dyanap (Pre, early Post)
Dual + Lorox (Pre, NT/P, NT/R)
Dual + Sencor or Lexone (PPI, Pre, NT/P, NT/R)
Dyanap + Lasso (Pre, early Post)
Furloe + Lasso (Pre)

Furloe + Treflan or Tolban (PPI)
Furloe + Vernam (PPI)
Lasso + Lorox (Pre, NT/P, NT/R)
Lasso + Lexone or Sencor (Pre, PPI, NT/P), NT/R)
Modown + Lasso (PPI, Pre)
Modown + Treflan (PPI)
Paraquat + Lorox (NT)
Paraquat + Sencor (NT)
Prowl + Amiben (Pre)
Prowl + Lorox (Pre)
Prowl + Sencor or Lexone (PPI, Pre)
Sencor + Amiben (Pre)
Sencor or Lexone + Treflan (PPI)
Surflan + Dyanap or Klean-Krop (Pre)
Surflan + Lorox (Pre, NT/P)
Surflan + Sencor or Lexone (Pre, NT/P)
Tolban + Sencor or Lexone (PPI)
Vernam + Treflan (PPI)

[1] PPI = preplant incorporated, Pre = preemergence, Post = postemergence, NT = no-till, NT/P = no-till with Paraquat, NT/R = no-till with Roundup.

The user can apply two treatments of the same herbicide (split application), or he can use two different ones, provided such uses are registered. Applying two herbicides at different times is referred to as a sequential or overlay treatment. Sequential treatment can be done in a number of ways. For example, a preplant application might be followed by a preemergence application, or a soil-applied treatment might be followed by a postemergence treatment. One herbicide may be broadcast while the other is banded or directed.

Herbicide Incorporation

Some herbicides must be incorporated to reduce surface loss caused by vaporization or photodecomposition. Those that are highly volatile need immediate incorporation. Incorporation of some herbicides may overcome some of the dependence upon rainfall.

Depth and thoroughness of incorporation depend upon type of equipment, depth and speed of operation, soil texture, and soil moisture. It is important to obtain uniform distribution, both horizontal and vertical, to prevent areas of high and low concentrations that may result in injury, residue, or poor control.

Since most annual weed seeds germinate in the top 1 or 2 inches of soil, most of the herbicide should be placed in that area. The tandem disk and field cultivator are most commonly used for incorporation. With either implement two passes may be required to obtain adequate herbicide uniformity. In general, it is best to make the second pass at some angle from, rather than parallel with, the first pass. With the tandem disk, most of the herbicide is at one-half to two-thirds of the depth at which the disk is operated. You can incorporate the herbicide more uniformly by using disks with blades that are less than 22 inches in diameter and spaced less than 8 inches apart. The field cultivator should be operated level at a minimum speed of 5 to 6 miles per hour. Mount a drag harrow behind the disk or field cultivator to level the ridges and give a light mixing.

Herbicides for Corn

All herbicides mentioned in this section are registered for use on field corn and silage corn. Herbicide suggestions for sweet corn and popcorn may be found in Circular 907, *1981 Herbicide Guide for Commercial Vegetable Growers*. Growers producing hybrid seed corn should check with the contracting company or inbred producer regarding tolerance of the parent lines.

Preplant Incorporation

Sutan+ and Eradicane should be incorporated immediately to minimize loss through vaporization. Incorporation is optional for many other soil-applied corn herbicides mentioned here. However, do not incorporate Banvel, Prowl, or propachlor. Preplant application should be done anytime during the 1 or 2 weeks prior to planting. Incorporation should distribute the herbicide evenly in the top 2 inches of soil. Incorporation of herbicides for which incorporation is optional may improve performance on some weed species, and if rainfall is limited it will improve performance on all weed species. However, do not apply herbicides too early or incorporate them too deep.

Sutan+ (butylate) or Eradicane (EPTC) may be applied anytime during the 2 weeks prior to planting. They should be incorporated immediately. Both herbicides are formulated with a crop safening agent to decrease the risk of corn injury. However, injury can still occur when growing conditions are unfavorable or when certain hybrids are used.

Sutan+ and Eradicane control the seedlings of annual grasses, shattercane, and johnsongrass. The suggested rate for these herbicides used alone or in combinations is 4¾ to 7⅓ pints per acre. Use the higher amount on heavy infestations of wild cane or yellow nutsedge or to suppress rhizome johnsongrass (see section on specific weed problems). A lower rate may be used on sandy soils.

You can control broadleaf weeds by tank mixing with atrazine or Bladex or by sequencing with an appropriate postemergence herbicide. The rate for combinations of Sutan+ or Eradicane with atrazine is 1¼ to 2 pounds of atrazine 80W (2 to 3 pints of 4L), while the rate for Bladex is 1½ to 2½ pounds of Bladex 80W (2 to 4 pints 4L). A combination of atrazine plus Bladex with Sutan+ is also registered.

Preplant or Preemergence Herbicides

Incorporation of the following herbicides is optional depending upon the weeds to be controlled and the likelihood of rainfall. Incorporation of these herbicides should be shallow but thorough.

AAtrex, Atrazine (atrazine), or Princep (simazine) can be applied anytime during the 2 weeks prior to planting, or soon after planting. Preplant incorporation of these herbicides controls weeds more effectively if rainfall is limited. Corn tolerance of atrazine and simazine is good, but carryover to subsequent crops can occur.

Princep controls fall panicum and crabgrass better than atrazine but is less effective in controlling cocklebur, velvetleaf, and yellow nutsedge. Princep is less soluble, but just as persistent, as atrazine. Thus, Princep is usually preplant incorporated. Princep plus atrazine can be used in 1:1 or 2:1 combinations; the total rate is the same as for atrazine used alone.

The rate for atrazine used alone is 2½ to 3¾ pounds of atrazine 80W, 4 to 6 pints of 4L, or 2.2 to 3.3 pounds of AAtrex 90WDG. Atrazine controls annual broadleaf weeds better than it does grasses, and it is often used at reduced rates in tank mix combinations to improve broadleaf weed control. The rate for atrazine in combinations is 1½ to 2 pounds of atrazine 80W, 2 to 3 pints of atrazine 4L, or 1.1 to 1.8 pounds of AAtrex 90WDG. These rates may not provide adequate control of cocklebur, morningglory, and velvetleaf but can reduce the risk of carryover.

You can minimize carryover injury by mixing and applying the herbicides accurately, by applying them early, by using the lowest rates consistent with good weed control, and by tilling the soil thoroughly before planting susceptible crops. The risk of carryover is greater the year after a cool, dry growing season and on soils with pH over 7.3.

If you use atrazine at more than 3 pounds of active ingredient per acre or if you apply after June 10, plant only corn or sorghum the next year. If you use atrazine in the spring and must replant, then plant only corn or sorghum that year. Do not plant small grains, small seeded legumes, or vegetables in the fall or spring. Soybeans planted the year after an application of atrazine can also be injured from carryover, especially if you use Sencor or Lexone.

Bladex (cyanazine) does not persist in the soil as long as atrazine, but atrazine does have the advantage of better corn tolerance. Bladex controls fall panicum and giant foxtail, but not broadleaf weeds, better than atrazine. Bladex can be combined with atrazine at 3:1, 2:1, or 1:1 ratios of Bladex to atrazine (see label for rates). The higher ratios will provide better grass control, while the 1:1 ratio will provide better broadleaf weed control.

Rates of Bladex must be selected accurately on the basis of soil texture and organic matter to reduce the possibility of corn injury. Rates are 1½ to 5 pounds of Bladex 80W, 1.2 to 4 quarts Bladex 4L, or 8 to 27 pounds of Bladex 15G per acre. You can lessen the risk of corn injury by using reduced rates of Bladex in combinations.

Bladex can be tank mixed with Lasso, Dual, propachlor, or Prowl to improve grass control. The Lasso or Dual combination can be applied immediately prior to planting or after planting. Do not incorporate the Prowl or propachlor combinations.

Lasso (alachlor) or Dual (metolachlor) can be applied preplant incorporated or at the preemergence stage. Preplant incorporation will improve control of yellow nutsedge and can lessen dependence upon rainfall. Incorporation should distribute the herbicide evenly in the top 2 inches of soil.

Lasso and Dual control annual grasses and help control yellow nutsedge. You can improve broadleaf weed control by using atrazine or Bladex in preplant combinations or by using atrazine, Bladex, or Banvel in preemergence combinations.

Lasso can be applied anytime during the week before planting corn and incorporated evenly into the top 2 inches of soil, or it can be used immediately after planting. The rate is 2 to 4 quarts of Lasso 4E or 16 to 26 pounds of Lasso 15G. Use the higher rate for the soil if you plan to incorporate Lasso.

Dual can be applied anytime during the 2 weeks prior to planting corn and incorporated into the top 2 inches of soil, or it can be used immediately after planting. The rates are 1½ to 3 pints of Dual 8E per acre.

Lasso or Dual plus atrazine can be applied preplant incorporated or after planting until corn is 5 inches tall and grass weeds are no larger than the 2-leaf stage. Do not apply with liquid fertilizer after the crop emerges. The suggested rate is 1½ to 2½ quarts of Lasso or 1¼ to 2½ pints of Dual 8E plus 1½ to 2½ pounds of atrazine 80W, 1 to 2 quarts of atrazine 4L, or 1.1 to 2.2 pounds of AAtrex 90WDG.

Dual is also cleared in a combination with atrazine plus Princep.

Bicep (metolachlor + atrazine) is a packaged mix of Dual plus atrazine. The rate is 2 to 4 quarts of Bicep 4.5L per acre.

Dual or Lasso plus Bladex can be applied prior to planting and incorporated, or they can be applied during the preemergence stage after planting. The rate is 2 to 2½ quarts of Lasso 4E or 1¼ to 2½ pints of Dual 8E plus 1 to 3 pounds of Bladex 80W or 1.6 to 4.8 pints of Bladex 4L. Adjust the rate carefully according to soil texture and organic matter.

Preemergence Herbicides

Banvel (dicamba) plus Lasso or Dual can be applied after planting until corn is 3 inches high. However, do not incorporate Banvel. Apply this treatment before grasses reach the 2-leaf stage. The addition of Banvel improves control of broadleaf weeds without creating risk of carryover injury. Banvel creates some risk of corn injury, especially if recommended rates are exceeded, applications are not accurate and uniform, or if corn is planted too shallow (less than 1½ inches). Do not use this treatment on coarse-textured soils or soils that are low in organic matter. The rate on soils with over 2½ percent organic matter is 1 pint of Banvel plus 2½ quarts of Lasso 4E, or 2 to 2½ pints of Dual 8E per acre.

Ramrod, Bexton, or Propachlor (propachlor) can be applied alone or with atrazine after the corn is planted but before grasses reach the 2-leaf stage. Granular formulations should be applied before crop or weeds emerge. Propachlor performs well on soils with over 3 percent organic matter.

Propachlor is irritating to the skin and eyes, so observe label precautions. Corn tolerance to propachlor is good. It controls annual grasses and pigweed. The rate is 6 to 9 pounds of propachlor 65W, 20 to 30 pounds of propachlor 20G, or 4 to 6 quarts of propachlor 4L per acre.

Propachlor can be mixed with atrazine or Bladex to improve broadleaf weed control. The rate is either 4½ to 6 pounds of propachlor 65W (2½ to 4 quarts 4L) plus 1½ to 2 pounds of atrazine 80W (1.2 to 1.6 quarts of 4L) or 1½ to 2¼ pounds of Bladex 80W (1.2 to 1.8 quarts of 4L) per acre.

Prowl (pendimethalin) is registered only for use on corn at the preemergence stage. Incorporation may result in serious corn injury. Use only where it is possible to cover seed adequately with soil. Prowl can control annual grasses and pigweed and provides some control of smartweed and velvetleaf. You can improve broadleaf weed control by combining Prowl with atrazine, Bladex, or Banvel. Prowl plus atrazine or Bladex may be applied in the early postemergence period before grasses are in the 2-leaf stage. The rate for such combinations is 1 to 1½ quarts of Prowl 4E. Do not use Prowl plus Banvel on sandy soils or soils with less than 1½ percent organic matter.

Postemergence Herbicides

Lasso, Dual, propachlor, or Prowl plus atrazine as well as Lasso or Dual plus Banvel can be used on corn between the preemergence and very early postemergence stages (see preemergence section). To get satisfactory control apply before grasses reach the 2-leaf stage.

Banvel plus atrazine can be applied up to 3 weeks after planting but before annual grasses are 1½ inches high. The rate is ½ pint of Banvel plus 1½ to 2 pounds of atrazine 80W or 1 to 1.6 quarts of atrazine 4L.

Atrazine can be applied before grass weeds are more than 1½ inches high. Many annual broadleaf seedlings are more susceptible than grass weeds and may be treated until they are up to 4 inches tall.

The addition of nonphytotoxic oils, oil-surfactant mixes, or surfactants has generally increased the effectiveness of postemergence atrazine. The nonphytotoxic oil is used at 1 gallon per acre. Crop-oil concentrates (80 percent oil and 20 percent surfactant) are used at the rate of 1 quart per acre. Surfactants are usually added at 0.5 percent of the total spray volume or about 1 pint per acre. Results with the oils and oil-surfactant mixes have generally been better than those with the surfactants.

Applications of atrazine and oil sometimes damage corn that has been under stress from prolonged cold, wet weather, or other factors. Do not use more than 2½ pounds of atrazine 80W or 2 quarts of atrazine 4L per acre if you mix with oil or oil concentrate. *Do not* add 2,4-D to the atrazine-oil treatment or severe injury may result. Mix the atrazine with water first and add the oil last. If atrazine is applied after June 10, do not plant any crop except corn or sorghum the next year.

Bladex (cyanazine) can be applied through the 4-leaf stage of corn growth but before weeds exceed 1½ inches in height. The rate is 1½ to 2½ pounds of Bladex 80W per acre. *(Do not use Bladex 4L.)* Injury to corn may occur under cold, adverse growing conditions. The injury may only be temporary yellowing, but can be more severe. Certain agricultural surfactants or vegetable oils may be added to Bladex, but do not use petroleum crop oils or apply with liquid fertilizers for postemergence application.

Banvel (dicamba) can be applied either early or late in the postemergence stage. If you apply it early, use it at a rate of ½ to 1 pint per acre anytime after planting until corn is 5 inches high. The best time to apply is at the first flush of broadleaf weeds. Banvel should be used in a sequential treatment with a grass herbicide such as Lasso, Dual, or Sutan+. Such timing allows for better crop tolerance than the preemergence treatments with Banvel, permits a higher rate than the later postemergence treatment, and diminishes the likelihood of significant soybean injury.

Banvel should be applied before soybeans in the area are 10 inches high. Soybean yields are seldom reduced when slight injury occurs early. However, yields can be reduced if severe injury occurs when soybeans are blooming or during pod fill. Banvel also can injure other susceptible plants, such as vegetables and ornamentals. Use extreme caution to avoid injury to desirable plants from either contaminated sprayers or drift of Banvel from treated areas.

Banvel may be applied until corn is 3 feet high or until 15 days before tasseling. When spraying near soybeans, do not spray corn after it is 2 feet high. If corn is more than 8 inches high, drop nozzles give better weed coverage and reduce drift. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn. The broadcast rate is ¼ to ½ pint per acre. Use the higher amount for taller and older weeds.

Do not use Banvel on sweet corn, popcorn, or seed corn. Do not graze or harvest corn for dairy feed before the ensilage (milk) stage.

A mixture of ¼ pint of Banvel plus ½ pint of 2,4-D amine (4 pounds per gallon) per acre is more economical than a full rate of Banvel and may present less risk of corn injury than 2,4-D alone. Use drop nozzles on corn more than 8 inches high when using the Banvel-plus-2,4-D mixture.

2,4-D is an economical and effective treatment for controlling many broadleaf weeds in corn. Use drop nozzles if corn is more than 8 inches high to decrease the possibility of injury. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn.

Do not apply 2,4-D to corn from tasseling to dough stage. After the hard dough to dent stage, you can apply 1 to 2 pints of certain 2,4-D's by air or high clearance equipment to control late-germinating broadleaf weeds that may interfere with harvest, or to suppress certain perennial weeds.

The suggested broadcast rate of acid equivalent per acre is ⅙ to ¼ pound of ester formulations or ½ pound of amine. This would be ⅓ to ½ pint of ester or 1 pint of amine for formulations with 4 pounds of 2,4-D acid equivalent per gallon.

The ester forms of 2,4-D can vaporize and injure nearby susceptible plants. This vapor movement is more likely with high-volatile than with low-volatile esters. Spray particles of either the ester or the amine form can drift and cause injury.

Corn is often brittle for 7 to 10 days after application of 2,4-D and thus is susceptible to stalk breakage from high winds or cultivation. Other symptoms of 2,4-D injury are stalk bending or lodging, abnormal brace roots, and failure of leaves to unroll.

High temperature and high humidity will increase the potential for 2,4-D injury, especially if corn is growing rapidly. If it is necessary to spray under these conditions, it may be wise to reduce the rate by about 25 percent. Corn hybrids differ in their sensitivity, and the probability of injury increases when corn is under stress.

Basagran (bentazon) is registered for postemergence use in corn in a manner similar to that for soybeans (see soybean section). Since corn is quite tolerant of Basagran, the addition of a crop-oil concentrate is considered relatively safe. Basagran is also cleared in combination with atrazine plus oil at the rate of 1 to 1½ pints of Basagran plus atrazine at 0.6 to 0.9 pound of 80W, 0.6 to 0.8 pound of 90WDG, or 1 to 1½ pints of 4L per acre. Oil concentrate is added at 1 quart per acre for control of annual broadleaf weeds only. The combination is more economical than Basagran alone and will reduce the carryover potential from atrazine alone.

Directed Postemergence Herbicides

Directed sprays are sometimes needed for emergency situations, especially when grass weeds become too tall for control with cultivation. However, weeds are often too large for directed sprays to be effective. Directed sprays cannot be used on small corn, and a height difference between corn and weeds is needed to keep the spray off the corn. Corn leaves that come into contact with the spray can be killed, and injury may affect yields.

Lorox (linuron) may be applied as a directed spray after corn is at least 15 inches high (free standing) but before weeds are 8 inches tall (preferably not more than 5 inches). Lorox controls grass and broadleaf weeds.

The broadcast rate is 1¼ to 3 pounds of Lorox 50W per acre, depending on weed size and soil type. Add Surfactant WK at the rate of 1 pint per 25 gallons of spray mixture. Cover the weeds with the spray, but keep it off the corn as much as possible. *Consider this an emergency treatment.*

Evik 80W (ametryn) is registered for directed use when corn is more than 12 inches tall and weeds are less than 6 inches tall. Evik should not be applied within 3 weeks of tasseling. The rate is 2 to 2½ pounds Evik 80W per acre (broadcast) plus 2 quarts of surfactant per 100 gallons of spray mixture. Extreme care is necessary to keep the spray from contacting the leaves. *Consider this an emergency treatment.*

Herbicides for Soybeans

Consider the kinds of weeds expected when you select a herbicide program for soybeans, especially when growing soybeans in narrow rows. The herbicide selectivity table (see last page) lists herbicides and their relative weed control ratings for various weeds.

Soybeans may be injured by some herbicides. However, they usually outgrow early injury with little or no effect on yield if stands have not been significantly reduced. Significant yield decreases can result when injury occurs during the bloom to pod fill stages. Excessively shallow planting may increase the risk of injury from some herbicides. Accurate rate selection is especially essential for Lorox, Lexone, and Sencor. Do not apply Lorox, Lexone, Sencor, or Modown after soybeans have begun to emerge. Follow label instructions as to rates, timing, incorporation, and restrictions. Lorox, Lexone, and Sencor are especially sensitive to soil type and should not be used on extremely sandy soils because of the likelihood of crop injury.

Preplant Herbicides

Incorporation is required for Basalin, Tolban, Treflan, and Vernam. Incorporation is optional for Amiben, Modown, Dual, Lasso, and Prowl when used alone and in some combinations. Surflan, Lorox, and Dyanap should not be incorporated. Incorporation can improve performance if rainfall is limited and may increase the effectiveness of Dual or Lasso in controlling nutsedge. Incorporation should distribute the herbicide evenly in the top 1 to 2 inches of soil. Deep incorporation or very early application of the herbicide can cause significant reductions in weed control.

Dinitroaniline herbicides registered for weed control in soybeans are Basalin, Tolban, Treflan, Prowl, and Surflan. Basalin, Treflan, and Tolban should be incorporated because of their low solubility and because of surface loss through vaporization and photodecomposition. Incorporation is optional with Prowl, but variable weed control and soybean injury may result from preemergence applications. Do not incorporate Surflan (see preemergence section).

How early you apply a dinitroaniline herbicide depends on the particular herbicide and on whether it is applied alone or in combinations. Combination treatments usually call for application within 7 to 14 days of planting. How long you delay incorporation depends on the herbicide, but delaying incorporation may lead to loss of herbicide from erosion, photolysis, or vaporization. Incorporation should distribute the herbicide evenly in the top 1 to 2 inches of soil (see label for implement settings). A deeper incorporation may improve shattercane and johnsongrass seedling control. Basalin, Tolban, and Treflan may be used for rhizome johnsongrass suppression (see section on specific weed problems).

The dinitroaniline herbicides control annual grasses, pigweed, and lambsquarters and may provide some control of smartweed and annual morningglory. Prowl and Surflan may also partially control velvetleaf. However, acceptable control of most tough broadleaf weeds requires combinations or sequential treatments with other herbicides. Sencor or Lexone can be tank mixed with any of the dinitroaniline herbicides.

These herbicides provide similar weed control, soybean tolerance, and persistence when recommended rates are used. However, to get equal control (specific activity) you must use different rates of the herbicides. Soybeans are sometimes injured by dinitroaniline herbicides. Plants that have been injured by incorporated treatments are stunted and develop swollen hyptocotyls and shortened lateral roots. Such injuries are not usually serious. Plants injured by preemergence applications develop stem callouses at the soil surface, which can cause lodging and yield loss.

Crops of corn, sorghum, or small grains may be injured if they are grown subsequent to a soybean crop that has been treated with a dinitroaniline herbicide. The symptoms are poor germination and stunted, purple plants with poor root systems. To avoid carryover use no more than the recommended rates. Also, be sure that application and incorporation are uniform. The likelihood of carryover increases with double cropping or late application and after a cool, dry season. Disking or chisel plowing provides for minimal dilution of herbicide residues.

Treflan (trifluralin) can be applied alone anytime in the spring. Combinations with Sencor or Lexone should be applied no more than 2 weeks prior to planting, while combinations with Amiben, Furloe, or Modown should be applied within a few days prior to planting. Incorporate as soon as possible, but do not delay incorporation more than 24 hours (8 hours if soil is warm and moist). The rate is 1 to 2 pints of Treflan 4E or 10 to 20 pounds of Treflan 5G per acre.

Tolban (profluralin) should be applied within a few days prior to planting soybeans. Incorporate within 4 hours of application. The rate is 1 to 3 pints of Tolban 4E per acre. Combinations may allow lesser amounts, although to control shattercane you may need to use the higher rate. Tolban can be tank mixed with Sencor, Lexone, or Furloe to improve broadleaf control.

Basalin (fluchloralin) can be applied anytime during the 8 weeks (alone) or 1 to 2 weeks (with Sencor or Lexone) prior to planting. Incorporate within 8 hours of application. The rate is 1 to 3 pints Basalin 4E per acre. Basalin can be combined with Sencor or Lexone to improve broadleaf weed control.

Prowl (pendimethalin) can be applied within 60 days (alone) or 7 days (with Sencor or Lexone) prior to planting soybeans or applied after planting (see preemergence). Preplant treatments should be incorporated within 7 days of application. Mechanical incorporation may not be necessary if adequate rainfall occurs. Rates are 1 to 3 pints of Prowl 4E per acre, although rates for combinations with Sencor or Lexone are lower than when the herbicide is used alone.

Sencor or Lexone (metribuzin) plus Basalin, Prowl, Treflan, or Tolban can be tank mixed and applied within 7 to 14 days of planting. Incorporate evenly into the top 2 inches of soil. The rate of Sencor or Lexone in these combinations is ½ to 1 pound of 50W, ½ to 1 pint of 4L, or ⅓ to ⅔ pound of 75DF. Use the normal rate, or slightly less, of the dinitroaniline herbicide (see labels).

Vernam (vernolate) controls annual grasses and pigweed. It sometimes provides fair control of annual morningglory, velvetleaf, and yellow nutsedge. Some soybean injury may occur in the form of delayed emergence, stunting, and leaf crinkling. Vernam can be applied within 10 days prior to planting and should be incorporated immediately. The broadcast rate is 2⅓ to 3½ pints of Vernam 7E or 20 to 30 pounds of Vernam 10G per acre. Vernam plus Treflan is labeled at the rate of 1 pint of Treflan plus 2⅓ to 3 pints of Vernam 7E per acre. The combination will reduce the risk of soybean injury, but it may also decrease control of velvetleaf and yellow nutsedge.

Preplant or Preemergence Herbicides

Lasso (alachlor) or Dual (metolachlor) can be applied to soybeans preplant incorporated or during the preemergence stage. If applied prior to planting, apply Dual anytime within the 2 weeks prior to planting and Lasso within 1 week of planting. If rainfall is limited, incorporation can improve performance and increase yellow nutsedge control. Soybeans are quite tolerant of Lasso or Dual. The first to second trifoliate leaves often appear crinkled with a drawstring effect on the middle leaflet, but these symptoms should not cause concern.

Lasso or Dual controls annual grasses plus pigweed and can help control nutsedge (see section on specific weed problems). These herbicides can be combined with Lexone, Sencor, or Amiben (incorporated or preemergence) and with Lorox or Dyanap (preemergence only) to improve broadleaf weed control. Lasso can also be combined with Modown.

The rate for Lasso is 2 to 4 quarts Lasso 4E or 16 to 26 pounds of Lasso II 15G per acre. The rate for Dual 8E is 1½ to 3 pints per acre. Use the higher amount for the soil when incorporating. The rate for combinations is about 75 percent of that for the herbicide used alone (see labels).

Amiben (chloramben) can be applied alone or with Treflan or Dual within a few days prior to planting. It can be applied preemergence alone or with Dual, Lasso, or Prowl to improve grass control, or with Lorox or Sencor. If it does not rain within 3 to 5 days of preemergence application, you should rotary hoe or harrow.

Amiben can control many weeds in soybeans, but do not expect control of cocklebur or annual morningglory. Control of velvetleaf and jimsonweed may be erratic, especially at lower rates or with low rainfall. Amiben occasionally injures soybeans, but damage is not usually severe. Injured plants are stunted and have abnormal, stunted roots.

The rate is 4 to 6 quarts Amiben 2S or 20 to 30 pounds of Amiben 10G per acre. The rate in most combinations is 3 to 4 quarts Amiben 2S per acre. Amiben is best suited to soils with over 2.5 percent organic matter.

Sencor or Lexone (metribuzin) can be applied anytime during the 1 to 2 weeks prior to planting and incorporated with Basalin, Dual, Lasso, Prowl, Treflan, or Tolban. Incorporation should distribute the herbicide evenly in the top 2 inches of soil. It can be applied preemergence by itself or with Amiben, Dual, Lasso, Prowl, or Surflan.

Sencor or Lexone can control many annual broadleaf weeds except annual morningglory. Control of giant ragweed, jimsonweed, and cocklebur is often marginal at the reduced rates necessary to minimize soybean injury.

One symptom of soybean injury is yellowing (chlorosis) of the lower leaves at about the first trifoliate stage or later; it may be followed by browning of leaves and death of plants depending upon the severity of the injury. Planting soybeans at least 1½ inches deep can reduce the risk of injury, but poor emergence may result because of soil crusting. Seedling diseases, weather stress, and atrazine carryover may increase the possibility of soybean injury. Injury may be greater on soils with pH over 7.3. Accurate, uniform application and incorporation are essential.

Adjust rates accurately according to soil conditions. *Do not apply to very sandy soil.* Combinations allow for reduced rates and thus minimize risk of soybean injury. The combination rate of Sencor or Lexone is ½ to 1 pound of 50W, ½ to 1 pint of 4L, or ⅓ to ⅔ pound of 75DF. You can use the higher amount when you apply this treatment during the preemergence stage, either alone or sequentially after application of a dinitroaniline herbicide. The higher amounts can improve broadleaf weed control, particularly of cocklebur, but they also increase the risk of soybean injury.

Modown (bifenox) can be applied preplant within a few days of planting in combination with Lasso or Treflan, or it can be applied immediately after planting alone or with Lasso. Do not apply Modown after the crop emerges. Incorporation can improve performance if rainfall is limited and can lessen the risk of soybean injury. Distribute the herbicide evenly in the top 1 to 2 inches of soil. Do not incorporate with a disk.

Soybeans may show stunting from Modown, especially from preemergence application. This injury is usually temporary and should not reduce yield. Modown controls smartweed and pigweed. Control of jimsonweed and velvetleaf is marginal, and control of morningglory and annual grasses is erratic. Combinations with Treflan or Lasso will improve annual grass control.

The rate with Lasso or Treflan is 2½ to 4 pints of Modown 4F or 1½ to 2½ pounds of Modown 80W with either 2 to 2½ quarts of Lasso 4E or 1 to 2 pints of Treflan 4E. Use the higher recommended rate of Modown when incorporating and on heavier infestations of weeds. The broadcast rate for the herbicide used alone is 2 to 2½ pounds of Modown 80W or 3 to 4 pints of Modown 4F.

Furloe Chloro IPC (chlorpropham) can be preplant incorporated with Treflan, Tolban, or Vernam; or it can be applied preemergence by itself or with Lasso to improve smartweed control. Preplant application should be done within a few days of planting soybeans, and incorporation should distribute the herbicide evenly in the top 1 to 2 inches of soil. The rate in sequential or tank mix combinations is 2 to 3 quarts of Furloe 4E per acre. Furloe 10G is used preemergence at 20 to 30 pounds per acre.

Preemergence Herbicides

Lorox (linuron) is best suited to silt loam soils that contain 1 to 3 percent organic matter. *Do not apply to very sandy soils.* Lorox controls broadleaf weeds better than grass weeds. It does not control annual morningglory, and control of cocklebur is variable. Accurate and uniform application, and proper rate selection are necessary to minimize the risk of crop injury. Tank-mix combinations allow the use of a reduced rate of Lorox to decrease the risk of soybean injury.

Lorox is registered in tank-mix combinations with Lasso, Dual, Prowl, or Surflan to improve grass control. The rate of Lorox in these combinations is 1 to 1½ pounds of Lorox 50W on silt loam soils with less than 3 percent organic matter.

Surflan (oryzalin) can control annual grasses, pigweed, and lambsquarters if there is adequate rainfall. You should rotary hoe to control emerging weeds if adequate rain does not fall within 7 days after application. Do not use on soils of more than 5 percent organic matter. The rate is 1 to 2 pounds per acre of Surflan 75W (¾ to 1½ quarts 4L) used alone or ⅔ to 1⅔ pounds of Surflan 75W in combinations. Surflan can be tank mixed with Lorox, Lexone, Sencor, Dyanap, or Klean-Krop to improve broadleaf weed control.

Prowl can be applied preemergence in combination with Amiben, Lexone, Lorox, or Sencor. When applied to the soil surface, Prowl may cause stem callousing, which can lead to soybean lodging and yield reduction. (See preplant section for more information.)

Dyanap (dinoseb plus naptalam) can be applied to soybeans from the time they are planted until the unifoliate leaves of the seedling unfold and expose the growing point. A tank mix of Dyanap plus Lasso, Dual, or Surflan is registered to improve grass control. Ancrack and Klean-Krop are other trade names for dinoseb plus naptalam. However, they are not registered in combination with Lasso or for postemergence application. They are registered for preemergence use with Surflan.

Postemergence Herbicides

Postemergence herbicides for soybeans are sometimes used as an emergency or "rescue" treatment. Early application will usually provide better control.

Soybeans may be injured by some of these postemergence herbicides. If there is a height difference between soybeans and weeds, the amount of soybean injury can be decreased by directing the spray toward the weeds, thus minimizing contact with the soybeans.

Dyanap is registered for early postemergence application (see preemergence section).

Premerge (dinoseb) can be applied in the early postemergence period when soybeans are still in the seedling stage before first leaves open to expose the terminal bud. To control emerged weeds such as cocklebur, morningglory, and jimsonweed, use 3 quarts per acre if the expected air temperature is below 75° F., and 2 quarts if it is from 75 to 95° F. Do not apply above 95° F. For residual control, Premerge can be tank-mixed with Amiben or Lasso. *Caution: Premerge is very toxic to man and animals.*

Amiben (chloramben) can be applied at 5 to 6 quarts per acre when soybeans are in the cracking to second trifoliate stage of growth. This treatment may control or suppress velvetleaf, smartweed, or nightshade, which is less than 4 inches tall.

Basagran (bentazon) can control many broadleaf weeds, such as cocklebur, jimsonweed, and velvetleaf. It is weak on pigweed, lambsquarters, and annual morningglory. It can provide some control of yellow nutsedge and Canada thistle but not of annual grasses.

The suggested rate for Basagran is ¾ to 1 quart per acre, depending on weed size and species. Application should be done when weeds are small (2-3 inches) and actively growing. These conditions usually exist when the soybeans are in the unifoliate to second trifoliate stage. Spraying during warm sunny weather can also improve performance. Use a minimum of 20 gallons of water per acre in order to get complete weed coverage. Adding a surfactant or crop-oil concentrate to Basagran may increase performance, particularly on yellow nutsedge, velvetleaf, and morningglory, but may cause some soybean injury.

Hoelon (dichlofop) may control many annual grass weeds and volunteer corn. Annual grass weeds should be in the 1- to 4-leaf stage of growth, volunteer corn should be less than 10 inches high, and soybeans should be at the fifth trifoliate stage or less. The rate is 2 to 3⅓ pints of Hoelon 3E per acre in at least 20 gallons of water. Because thorough coverage of the foliage is essential, a minimum pressure of 20 pounds per square inch is recommended. Do not use Hoelon in a tank mixture with other postemergence herbicides. *Hoelon is a restricted-use herbicide.*

Blazer (acifluorfen) is a postemergence herbicide used to control broadleaf weeds in soybeans. The rate is 2 pints of Blazer 2S when broadleaf weeds are at the 2- to 4-leaf stage and growing actively. Blazer controls annual morningglory, black nightshade, and pigweed better than Basagran, but Basagran is better on cocklebur and velvetleaf. Blazer is primarily a contact herbicide. Suggested spray volumes are 20 to 40 gallons per acre with a spray pressure of 40 pounds per square inch. Surfactants or crop oils are not recommended with Blazer. Do not spray if rain is anticipated within 6 hours.

Dyanap (dinoseb plus naptalam) can be applied to soybeans after the second trifoliate leaf opens until beans become 20 inches tall. Two to 3 quarts per acre is recommended for control of cocklebur, jimsonweed, smartweed, and annual morningglory less than 3 inches tall. Four quarts per acre may control cocklebur and jimsonweed taller than 3 inches. A split application of 2 quarts at the second trifoliate stage followed by 2 quarts 10 to 14 days later is recommended for severe weed infestations.

Best results are obtained by using high pressure (40 to 60 pounds per square inch) and 8 to 10 gallons of water per acre. Although leaf burn can occur, the crop usually recovers within 2 to 3 weeks with little or no yield loss. Do not apply Dyanap to wet soybean foliage.

Directed Postemergence Herbicides

Roundup (glyphosate) can be applied through several types of selective applicators — recirculating sprayers, wipers, or rope wicks. This application is particularly useful for control of volunteer corn, common milkweed, and johnsongrass. Weeds should be a minimum of 6 inches above the soybeans. Avoid contact with the crop. Equipment should be adjusted so that the lowest spray stream or wiper contact is at least 2 inches above the soybeans. For calibration of equipment, refer to the Roundup label. If you use a recirculating sprayer, apply 4 quarts of Roundup in 20 gallons of water to suppress perennial broadleaf weeds. To control perennial grass and annual weeds, use 2 to 3 quarts of Roundup in 20 gallons of water. For wiper or roller type applicators, mix 1 to 2 gallons of Roundup in 20 gallons of water. Use the higher amount for heavy weed infestations, perennial weeds, and annual broadleaves. For rope wick applicators, mix 1 gallon of Roundup in 2 gallons of water.

Butoxone SB and Butyrac 200 (2,4-DB) are used for directed postemergence control of cocklebur in soybeans. 2,4-DB also may give some control of annual morningglory and giant ragweed. Consider 2,4-DB for emergency control of cocklebur when potential benefit from weed control is more significant than risk of soybean injury. Injury symptoms include leaf wilting, stem curvature, and cracking of stems. 2,4-DB alone or in combination with Lorox can be directed when soybeans are at least 8 inches high and cocklebures are less than 4 inches high. Do not spray on more than the lower third of the soybean plant.

Lorox plus 2,4-DB, or Paraquat alone are also cleared for directed postemergence treatment in soybeans. Soybeans must be at least 8 inches tall and weeds not over 2 inches tall. Nozzles must be adjusted accurately to spray only the lower one-third of the soybean plant or serious soybean injury can occur. Read the labels for the correct rates and precautions.

Paraquat Harvest Aid

Paraquat is registered for drying weeds in soybeans just before harvest. For indeterminate varieties (most Illinois varieties), apply when 65 percent of the seed pods have reached a mature brown color or when seed moisture is 30 percent or less. For determinate varieties, apply when beans are fully developed, at least one-half of the leaves have dropped, and remaining leaves are turning yellow.

The rate is ½ to 1 pint of Paraquat per acre. The higher rate is for cocklebur. The total spray volume per acre is 2 to 5 gallons per acre for aerial application or 20 to 40 gallons for ground application. Add 1 quart of Ortho X-77 Spreader per 100 gallons of spray. Do not pasture livestock within 15 days of treatment, and remove livestock from treated fields at least 30 days before slaughter.

No-Till and Double-Crop

Corn and soybeans are sometimes produced without seedbed preparation, either in last year's crop residue (no-till) or as a second crop after small grain harvest or forage removal (double-crop). The no-till concept of planting has greatly improved the probability of success of double-cropping by conserving soil, soil moisture, and time.

No-till herbicides must control both vegetation existing at planting and seedling weeds that germinate after planting. Existing vegetation may be a perennial grass sod, a legume or legume-grass sod, an annual cover crop, or weeds that emerge in the previous years' crop stubble before planting. If a cutting of forages such as alfalfa or clover is removed before no-till planting, control of sod may be poor. Labeled applications of 2,4-D, Roundup, or Banvel can improve control of broadleaf perennials when used in registered crops, such as corn or sorghum.

Several precautions should be observed in no-till cropping systems. Crop seed should be planted to the proper depth and adequately covered to avoid possible contact from herbicide sprays. (Several herbicide labels give planting depths necessary to avoid possible injury.) Preemergence applications of the herbicide treatment may give better weed control than preplant applications since the planting process may expose untreated soil containing viable weed seed. The total reliance on chemical weed control and large amounts of crop residue present under no-till cropping systems may require that the higher labeled herbicide rates be used to obtain acceptable weed control.

Paraquat (1 or 2 pints per acre) plus a *nonionic* surfactant, such as Ortho X-77, at ½ pint per 100 gallons of diluted spray is generally used to "knock down" existing foliage before crop emergence. Since Paraquat provides only contact action, a minimum of 40 gallons or more of spray per acre is suggested to insure adequate coverage of the foliage. *Paraquat is a restricted-use pesticide.*

Roundup (3 pints per acre) should be considered as an alternative treatment for control of the foliage prior to crop emergence in situations where fall panicum, smartweed, or certain perennial weeds are a problem.

No-till Corn

Herbicides registered with Paraquat plus atrazine are Dual, Lasso, Princep, and Bladex. Dual plus Princep, atrazine plus Princep, and Bicep are also registered with Paraquat. These combinations give better control of annual grasses than atrazine or Bladex plus Paraquat.

Herbicides registered with Roundup plus atrazine or Princep are Dual and Lasso. Roundup is also registered with atrazine plus Princep, atrazine plus Princep plus Dual, Lasso plus Bladex, and Bicep for no-till use in corn.

No-till or Double Crop Soybeans

Preemergence herbicides registered in soybeans as tank mixes with Paraquat (1 to 2 pints per acre) plus Ortho X-77 surfactant are Lorox, Sencor, or Lexone alone or in combination with Lasso, Dual, or Surflan. Registered tank mixes with Roundup are Lasso or Dual in combination with Lorox, Sencor, or Lexone.

Herbicides for Sorghum

Atrazine may be used for weed control in sorghum (grain and forage types) or sorghum-sudan hybrids. Application may be made preplant, preemergence, or postemergence.

Injury may occur when sorghum is under stress from unusual soil or weather conditions or when rates are too high. The rate of application for preplant and preemergence is 2 to 3 pounds of atrazine 80W per acre. The postemergence rate is 2½ to 3¾ pounds per acre. Rotational crop recommendations and weed control are the same as for atrazine used in corn. Failure to control fall panicum has been a major problem.

Ramrod, Bexton, or Propachlor (propachlor) may be used alone or in combination with atrazine, Milogard, Bladex, or Modown for sorghum. Propachlor will improve grass control, but rates must not be skimpy, especially on soils relatively low in organic matter. For specific rates, consult the product label.

Dual (metolachlor) alone or with atrazine or Bicep can be used on sorghum seed that has had the Concep treatment. These herbicides will improve grass control more than atrazine applied alone.

Milogard (propazine) has better sorghum tolerance than atrazine, but grass control is not as good. Only corn or sorghum may be planted in rotation within 12 months after treatment.

2,4-D may be applied postemergence for broadleaf control in 4- to 12-inch tall sorghum. Use drop nozzles if sorghum is more than 8 inches tall. Rates are similar to those for use in corn.

Herbicides for Small Grains

Small grains seeded in the fall or early spring often compete very well with most weeds if the stand is good and a good fertilization program is followed. Herbicide suggestions for small grains underseeded with a legume differ from those for small grains growing alone. If wild garlic is a problem, do not underseed with a legume; see the specific weed section for herbicide suggestions.

2,4-D is used to control certain broadleaf weeds. Winter wheat is more tolerant of 2,4-D than oats, but do not spray wheat in the fall. Small grains can be sprayed in the spring after the plants (wheat or oats) have fully tillered but before they begin rapid stem elongation. Spraying in the boot stage may injure the crop and reduce yield. If the small grain is underseeded with a legume, use only the amine formulation of 2,4-D at ½ pint per acre. If there is no legume underseeding, apply 1 pint of 2,4-D amine or ⅔ pint of 2,4-D ester per acre. Ester formulations are suggested for control of wild garlic (see specific weed section).

MCPA is less likely to damage oats and legume underseedings than 2,4-D, but it is more expensive and will not control as many different weed species. For small grains underseeded with a legume, use ¼ pound per acre (active ingredient) when the small grain is between the tiller and boot stages and when legumes are 2 to 3 inches tall.

Banvel (dicamba) should not be used on small grains that have a legume underseeding. It will control wild buckwheat and smartweed better than 2,4-D but is poorer for controlling mustards. It may be used alone or in combination with 2,4-D. Banvel should be applied after winter wheat has fully tillered and before it begins to joint (nodes begin to form in the stem). Do not apply later or lodging and yield reductions can occur. The rate is ¼ pint of Banvel alone or with 4 to 6 ounces of 2,4-D (active ingredient) per acre.

Small Grain Stubble Fields

Stubble fields of small grains that have not been underseeded with a legume or double-cropped often are neglected and become infested with weeds after harvest. Tillage may subject the land to erosion. Mowing may control some weeds, but many species grow back rapidly.

In small grain stubble not underseeded with legumes, most broadleaf weeds can be controlled with 2,4-D, and dalapon can control many grasses. Rates may be varied depending on the kind and size of weeds present. Usually ¼ to 1 pound of 2,4-D and 3 to 7 pounds of dalapon provide adequate control. Weeds should be treated when they are actively growing. Be sure to follow label directions carefully.

Herbicides for Forage Crops

Weed control in alfalfa and clovers differs according to crop species and type of seeding — crop alone (pure seeding) or in combination with a grass species. Be sure to consult the label for proper use. Alfalfa and most clovers can be established without a companion crop and where there is not a forage grass-legume mixture by using Eptam or Balan.

Seedling Establishment

Eptam 7E (EPTC) is used at a rate of 3½ to 4½ pints per acre and immediately incorporated just before planting. It is most effective on grasses and also can give some control of nutsedge, especially at the higher rates.

Balan (benefin) is incorporated at a rate of 3 to 4 quarts per acre and may be applied up to 10 weeks before planting. Balan will control many annual grasses and some broadleaf weeds.

Butoxone or Butyrac (2,4-DB) can be used postemergence to control broadleaf weeds in alfalfa and most clovers after the companion crop is removed or in legume-only or legume-grass seedings established without a companion crop. The rate is 1 to 2 quarts per acre of ester formulations or 1 to 3 quarts of the amine formulation. Do not use ester formulations on most clovers. Do not graze livestock on or cut hay from treated fields within 30 days after treatment. 2,4-DB can also be used in established legumes.

Established Legumes

Princep (simazine) can be applied to pure alfalfa stands established more than 12 months. Apply after the last cutting in the fall. Princep can control many grasses and broadleaf weeds but will not control most well-established perennial or biennial weeds. The rate is 1 to 1½ pounds per acre of Princep 80W, depending on soil type. If excessive amounts are used, applications are made at the wrong time, or unfavorable conditions exist, crop injury can occur. *Do not apply on sandy soils.*

Kerb (pronamide) can be applied in the fall to established stands of clover, birdsfoot trefoil, crown vetch, or alfalfa. It will control most annual grass and broadleaf weeds and help suppress quackgrass. Do not apply to mixed stands of legumes and forage grasses. Rates vary from 2 to 4 pounds of Kerb 50W per acre. Do not graze or harvest for forage for at least 120 days following treatment.

Sinbar (terbacil) can be applied to pure stands of alfalfa that are at least a year old. It controls many annual grasses and broadleaf weeds. Apply ½ to 1½ pounds per acre when alfalfa is dormant (fall or spring) but not when the ground is frozen. Injury may result when it is used on certain types of soil or under unfavorable growing conditions.

Sencor or Lexone (metribuzin) can be used in established stands of alfalfa or alfalfa-forage grass mixtures. Higher rates will reduce stands of forage grasses in the mixtures. It should be applied early in the spring before growth begins or in the fall after alfalfa growth ceases. The rate is ¾ to 2 pounds of 50W or ¾ to 2 pints of 4L, depending upon the weed species to be controlled. Do not graze or harvest within 28 days after application.

Paraquat can be applied at 2 to 3 pints per acre in 50 to 60 gallons of water to dormant alfalfa to control certain winter annuals and suppress perennial grasses. Apply to well-established stands after the last fall cutting when the crop is dormant or before spring growth reaches 1 inch. Add Ortho X-77 Spreader at 1 to 2 pints per 100 gallons of spray mix. Do not graze, cut, or harvest within 60 days of application.

Furloe Chloro IPC (chlorpropham) may be applied to dormant pure alfalfa stands that are established or to newly seeded alfalfa with 3 or more trifoliate leaves. Application for control of chickweed and downy brome may be made from October through January using 1 to 2 quarts of the 4 EC. Beginning in February, 2 to 3 quarts can be used. Do not apply within 40 days of harvest.

Herbicides for Grass Pastures

Pasture weed control must be part of a total program of good management that includes proper grazing, good fertilization, and reseeding as necessary. For information on control of multiflora rose see the section on specific weed problems.

2,4-D at ½ to 1 pound per acre should control most broadleaf weeds. A higher rate may be needed for the control of more resistant weeds and some perennials. Certain woody species, such as buckbrush and willow, can also be controlled with foliar applications of 2,4-D. Milk cows should not be grazed on treated land for 7 days after treatment.

Banvel (dicamba) can control many broadleaf weeds when used at a rate of 1 to 4 pints per acre. Delay grazing 7 to 40 days and delay harvest 37 to 70 days, depending on the amount applied. Do not use where desirable legumes are present. Avoid injury to other nearby plants that are susceptible to Banvel. Do not graze or harvest for dairy feed until 60 days after treatment.

Ammate (ammonium sulfamate) is nonselective but can be considered for spot brush treatment in pastures. It can be applied as a foliar spray or as a stump treatment for brush control. Sprayers should be thoroughly cleaned after each use because Ammate is corrosive to metals.

Tordon 10K (picloram) is a pelleted formulation registered for treatment of certain brush species in pastures. Tordon 10K may be applied to a maximum of 25 percent of the pasture anytime the soil is not frozen. Spread the pellets within the dripline of the undesired plant at 20 to 40 pounds per acre (0.5 to 1.0 pound per 1000 square feet). Recommended rates will not injure most grass species. Use extreme care with Tordon to avoid contact with desirable susceptible plants such as soybeans. Movement may occur with surface water or through the air as drift. *Tordon is a restricted-use pesticide.*

Specific Weed Problems

Yellow Nutsedge

Yellow nutsedge is a perennial sedge with a triangular stem. It reproduces mainly by tubers. Regardless of the soil depth at which the tuber germinates, a basal bulb develops 1 to 2 inches under the soil surface. A complex system of rhizomes (underground stems) and tubers develops from this basal bulb. Yellow nutsedge tubers begin sprouting about May 1 in central Illinois. For the most effective control, soil-applied herbicides should be incorporated into the same soil layer in which this basal bulb is developing.

For soybeans, a delay in planting until late May allows time for two or three tillage operations to destroy many nutsedge sprouts. Tillage helps deplete food reserves in nutsedge tubers. Row cultivation is helpful. Preplant applications of Lasso, Dual, or Vernam will also help.

Lasso (alachlor) applied preplant incorporated at 2½ to 4 quarts per acre (½ quart more than for surface-applied rates) often gives good control of nutsedge.

Dual (metolachlor) can be applied at 1½ to 3 pints of 8E per acre to control nutsedge. Preplant treatment is preferred to treatment at the preemergence stage.

Vernam 7E (vernolate) applied preplant at 3½ pints per acre is also effective against yellow nutsedge. Immediate incorporation is necessary with Vernam.

Basagran (bentazon) is a postemergence treatment that can also help control nutsedge in soybeans. One quart per acre can be applied when nutsedge is 6 to 8 inches tall. A split application (two treatments) of Basagran has also been registered. Addition of a crop-oil concentrate to Basagran may improve performance.

For corn, preplant tillage before nutsedge sprouts is of little help in control. Timely cultivation gives some control, but a program of herbicides plus cultivation has provided the most effective control of nutsedge.

Several preplant treatments are available. **Eradicane (EPTC) or Sutan+ (butylate)** at 4¾ to 7⅓ pints per acre are effective for control of yellow nutsedge in corn. They must be incorporated immediately. **Lasso** or **Dual** applied in corn as for soybeans can also be quite effective.

The combinations of Lasso, Dual, Sutan+, or Eradicane incorporated with atrazine may give better control of nutsedge while also controlling broadleaf weeds.

Atrazine or Bladex (cyanazine) is used as a post emergence spray to control emerged yellow nutsedge when it is small. Split applications of atrazine plus oil have been more effective than single applications. **Basagran** can be used in corn in a manner similar to that for soybeans. **Lorox (linuron)** directed postemergence spray has also given some control.

Johnsongrass

Johnsongrass can reproduce both from seeds and by rhizomes. Both chemical and cultural methods are needed to control johnsongrass rhizomes.

Much of the rhizome growth occurs after the johnsongrass head begins to appear. Mowing, grazing, or cultivating to keep the grass less than 12 inches tall can reduce rhizome production significantly.

Control of johnsongrass can also be improved with tillage. Fall plowing and disking bring the rhizomes to the soil surface, where many of them are winter-killed. Disking also cuts the rhizomes into small pieces, making them more susceptible to chemical control.

Johnsongrass rhizomes can be controlled or suppressed using certain herbicides in various cropping programs. Several preplant incorporated herbicides can provide control of johnsongrass seedlings in soybeans or corn (see the table at the end of this article).

Treflan (trifluralin), Tolban (profluralin), or Basalin (fluchloralin) used in a 3-year soybean program has been fairly successful in controlling rhizome johnsongrass. They are used at 1½ to 2 times the normal rate each year for 2 years, and then either at the normal rate, or another suitable herbicide is used the third year before resuming a regular cropping sequence. Thorough preplant tillage and incorporation are necessary for satisfactory control. Be certain not to plant such crops as corn or sorghum following application of these herbicides at the higher rates.

Eradicane (EPTC) or Sutan+ (butylate) will suppress rhizome johnsongrass in corn when used at a rate of 7⅓ pints per acre as a preplant incorporated treatment. However, this increase in rate also increases the risk of corn injury.

Dalapon can be used to treat emerged johnsongrass before planting corn or soybeans. Apply 5 to 7 pounds per acre after the grass is 8 to 12 inches tall. Plow or disk after 3 days and then delay planting corn or soybeans at least 1 week. See the label for specific intervals.

Dalapon can also be used to control johnsongrass after wheat that is not double cropped or undersown with a legume. A combination of mowing, timely dalapon application, and tillage has provided quite effective control of johnsongrass.

Roundup (glyphosate) can be used as a spot treatment to control johnsongrass in corn, soybeans, or sorghum. Apply 2 to 3 quarts when johnsongrass has reached the boot to head stage and is actively growing. Use of Roundup in wick or recovery-type sprayers is effective for control of johnsongrass in soybeans. (See section on directed postemergence herbicides for soybeans.)

Roundup may be applied in small grain stubble when johnsongrass is in the early head stage. Fall applications should be made before the first frost. At least 7 days should be allowed after treatment before tillage.

Quackgrass

Quackgrass is a perennial grass with shallow rhizomes. Most preemergence herbicides will not control it.

Atrazine is quite effective when used as a split application in corn. Apply 2½ pounds of atrazine 80W per acre in the fall or spring and plow 1 to 3 weeks later. Another 2½ pounds per acre should be applied as a preplant or preemergence treatment. Postemergence application is usually less effective. A single treatment with 3¾ to 5 pounds per acre can be applied either in the spring or fall 1 to 3 weeks before plowing, but the split application usually gives better control of annual weeds. If more than 3 pounds of atrazine is applied per acre, do not plant crops other than corn or sorghum the following year.

Eradicane (EPTC) can be used to suppress quackgrass in corn where more flexibility in cropping sequence is desired. A rate of 4¾ pints per acre of Eradicane 6.7E can be used on light infestations, while 7⅓ pints per acre is suggested for heavier infestations. There is some risk of corn injury, especially at the higher rate. A tank mix with atrazine should improve control.

Dalapon can be applied to quackgrass 4 to 6 inches tall in the spring at a rate of 8 pounds per acre. Plow after 4 days and delay planting corn for 4 to 5 weeks. Up to 15 pounds of dalapon per acre may be used in the fall.

Roundup (glyphosate) can be used for controlling quackgrass before planting either corn or soybeans. Apply 2 to 3 quarts per acre when quackgrass is 8 inches tall and actively growing (fall or spring). Delay tillage for 3 or more days after application.

Canada Thistle

Canada thistle is a perennial weed that has large food reserves in its root system. There are several varieties of Canada thistle. They differ not only in appearance but also in their susceptibility to herbicides.

2,4-D may give fairly good control of some strains. Rates will depend on where the thistle is growing. For example, higher rates can be used in grass pastures or in noncrop areas than can be used in corn. **Banvel** often is a little more effective than 2,4-D and may be used alone or in combination with 2,4-D.

Atrazine and oil applied postemergence has been fairly effective in controlling Canada thistle in corn. Make the application before thistles are 6 inches tall.

Basagran (bentazon) can be used for control of Canada thistle in soybeans or corn when the thistles are 8 to 12 inches tall. Apply ¾ to 1 quart per acre in a single application, or for better control make two applications of ¾ to 1 quart per acre each, 7 to 10 days apart.

Roundup (glyphosate) can be used at 2 to 3 quarts per acre when Canada thistle is at or beyond the early bud stage. Fall treatments must be applied before frost for best results. Allow 3 or more days after application before tillage.

Amitrole or Amitrole-T effectively controls Canada thistle, but can be used only in noncrop areas. **Tordon (picloram)** gives good control of Canada thistle, but soybeans and most other broadleaf plants are extremely sensitive to it. Use only on noncropland.

Wild Garlic and Wild Onion

Wild garlic and wild onion are perennials that sprout in the fall and form aerial bulblets in May. The aerial bulblets may be harvested with the grain. Such contaminated wheat is often docked to feed grain prices or even refused at elevators.

Wild garlic and wild onion are not usually problems in corn and soybeans. Fall or early spring plowing plus spring tillage and cultivation greatly reduce the growth and reproduction of these weeds. Three or 4 years of such a program greatly reduces the problems of wild garlic and wild onion.

2,4-D can be applied to winter wheat in the spring after the wheat tillers but before it reaches the boot stage (wheat head still inside the stem). The proper time to spray winter wheat is usually late March or early April.

Ester formulations of 2,4-D have provided better control than have amine formulations. A rate of ½ to 1 pound of 2,4-D ester or ¾ to 1½ pounds of 2,4-D amine per acre may be used. These rates may reduce wheat yields and probably will kill legume underseedings. Only about a third to a half of the wild garlic or wild onion will be killed, but the remaining plants may be so distorted that the combine header can be set to miss most of the aerial bulblets.

2,4-D is used on corn stubble fields or on grass pastures in the late fall or early winter. In grass pastures, 1 to 2 pounds of 2,4-D ester per acre applied in late fall or early spring may give effective control of wild garlic and wild onion.

Multiflora Rose

Multiflora rose is a woody perennial that is spreading into many permanent pastures in Illinois. The plant has numerous sharp thorns along the stems (canes) that prevent livestock from grazing among its canes. Seeds produced by the plant are rapidly spread by wildlife.

Banvel (dicamba) should be applied in early spring when foliage and stems are actively growing but before flower bud formation. Mix 1 gallon of Banvel in 99 gallons of water (3 tablespoons of Banvel per gallon of water). Uniform wetting of stems and foliage is required for best results. Do not allow spray to drift to desirable plants.

Tordon 10K (picloram) is a pelleted formulation that is applied to the soil surface above the active roots of multiflora rose. Active roots may extend beyond the drip-line of the plants. Rainfall is required to dissolve the pellet and carry the herbicide into the root zone where it is absorbed. Uniformly apply 40 pounds of Tordon 10K per acre (3 oz. per 100 square feet). Do not apply above the roots of desirable trees or where runoff may occur or treat over 25 percent of the pasture.

Krenite (fosamine) is cleared for noncropland only. Apply Krenite in August and September prior to leaf senescence. Use 1 to 1½ gallons of Krenite plus 1 quart of a nonionic surfactant per 100 gallons of spray to completely cover stems and foliage. Control will not be evident until spring. Krenite will not injure most grasses and legumes grown in Illinois.

Roundup (glyphosate) is cleared for noncropland control of multiflora rose. Apply to actively growing stems and foliage when most plants are at or beyond the early to full bloom stage of growth. Use 2 quarts of Roundup per acre or apply as a 1 percent solution (1 gallon of Roundup per 100 gallons of water) with hand-held equipment. Thorough coverage is essential for best results.

Additional Information

Not all herbicides and herbicide combinations available are mentioned in this publication. Some are relatively new and are still being tested. Some are not considered to be very well adapted to Illinois or are not used very extensively. For further information on field crop weed control, consult your county Extension adviser or write to the Department of Agronomy, N-305 Turner Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801.

Relative Effectiveness of Herbicides on Major Weeds

This chart gives a general comparative rating. Under unfavorable conditions, some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions, control may be better than indicated. Type of soil is also a very important factor to consider when selecting herbicides. Rate of herbicide used also will influence results. G = good, F = fair or variable, and P = poor.

		Grasses							Broadleaf Weeds									
	Crop tolerance	Foxtail	Barnyardgrass	Crabgrass	Fall panicum	Johnsongrass seedlings	Shattercane	Yellow nutsedge	Annual morningglory	Cocklebur	Jimsonweed	Lambsquarters	Nightshade, black	Pigweed	Ragweed, common	Ragweed, giant	Smartweed	Velvetleaf
SOYBEANS																		
Preplant																		
Treflan, Tolban, Prowl, Basalin	F-G	G	G	G	G	G	G	P	F-P	P	P	G	P	G	P	P	P-F	P
Sencor, Lexone + dinitroaniline	F	G	G	G	G	G	G	P	F	F	F-G	G	P	G	G	F	G	F-G
Vernam	F	G	G	G	G	G	G	F	F-P	P	P	F	P	G	P	P	P	F
Preplant or Preemergence																		
Amiben	F-G	G	F-G	F-G	F-G	F	F	P	P	P	P-F	G	F	G	F-G	F	F-G	F
Lasso, Dual	G	G	G	G	G	P-F	P-F	F-G	P	P	P	F	F	G	P-F	P	P-F	P
Lasso, Dual + Sencor, Lexone	F	G	G	G	G	P	P	F	P	F	F-G	G	F	G	G	F	G	F-G
Lasso, Dual + Lorox[1]	F	G	G	G	G	P	P	P-F	P	F	F	G	F	G	G	F	G	F-G
Lorox[1]	F	F	F	F	F	P	P	P	P	F	F	G	F	G	G	F	G	F-G
Modown	F	F	F	F	F	P	P	P	F-P	P	F	G	F	G	F	P	G	F
Sencor, Lexone[1]	F	F	F	F	F	P	P	P-F	P	F	F-G	G	P	G	G	F	G	F-G
Postemergence																		
Basagran	F-G	P	P	P	P	P	P	F	P-F	G	G	F	P	F	F	F	G	F-G
Blazer	F	P	P	P	P	P	P	P	F-G	F	G	F	F	F-G	F	F	G	P
Dyanap	F	P	P	P	P	P	P	P	F	G	G	F-G	P	F-G	F	F	F	P-F
2,4-DB	P-F	P	P	P	P	P	P	P	F-G	G	P-F	F	P	F	F	F	P	P
Hoelon	G	F-G	F	F-P	F	P	P	P	P	P	P	P	P	P	P	P	P	P
CORN																		
Preplant																		
Sutan+, Eradicane	F-G	G	G	G	G	F-G	F-G	F-G	P	P	P	P-F	F	G	P	P	P	F
Sutan+, Eradicane + atrazine, Bladex	F-G	G	G	G	G	F-G	F-G	F-G	F-G	F-G	G	G	G	G	G	F	G	F-G
Princep + atrazine	G	F-G	F-G	F	F	P	P-F	P	F-G	F-G	G	G	G	G	G	G	G	F
Preplant or Preemergence																		
Atrazine	G	F-G	F	P	P	P	P	F	G	F-G	G	G	G	G	G	G	G	F-G
Banvel + Lasso, Dual	F-G	G	G	G	G	P	P	F	P-F	F	F-G	G	G	G	G	F	G	F
Bladex	F-G	F-G	F-G	F-G	G	P	P	P	F	F-G	G	G	G	F	G	F-G	G	F
Bladex + atrazine	F-G	F-G	F	F	F-G	P	P	P	F-G	F-G	G	G	G	G	G	F-G	G	F-G
Lasso, Dual	F-G	G	G	G	G	P-F	P-F	F-G	P	P	P	F	F	G	P-F	P	P-F	P
Lasso, Dual + atrazine, Bladex	F-G	G	G	G	G	P	P	F-G	F-G	F	G	G	G	G	G	F	G	F
Prowl + atrazine, Bladex[1]	F-G	G	G	G	G	F	F	P	F-G	F	G	G	G	G	G	F	G	F-G
Propachlor + atrazine, Bladex[1]	G	G	G	F-G	F	P	P	P-F	F-G	F	G	G	G	G	G	F	G	F
Ramrod, Bexton, Propachlor[1]	G	G	F	F-G	F	P	P	P-F	P	P	P	F	P	G	P	P	P	P
Postemergence																		
Atrazine + oil	F-G	F-G	G	P	P	P	P	F	G	G	G	G	G	G	G	F	G	F-G
Banvel	G	P	P	P	P	P	P	P	G	G	G	G	G	G	G	G	G	F
Basagran	G	P	P	P	P	P	P	F	P-F	G	G	F	P	F	F	F	G	F-G
Bladex	F-G	G	G	F	F-G	P	P	F	F	F-G	G	F	G	F-G	G	F	G	F
2,4-D	F-G	P	P	P	P	P	P	P	G	G	F	G	F	G	G	G	P-F	F-G

[1] Preemergence only

Useful Facts and Figures

To convert column 1 into column 2, multiply by	Column 1	Column 2	To convert column 2 into column 1, multiply by
	Length		
.621	kilometer, km	mile, mi.	1.609
1.094	meter, m	yard, yd.	.914
.394	centimeter, cm	inch, in.	2.54
16.5	rod, rd.	feet, ft.	.061
	Area		
.386	kilometer², km²	mile², mi.²	2.59
247.1	kilometer², km²	acre, acre	.004
2.471	hectare, ha	acre, acre	.405
	Volume		
.028	liter	bushel, bu.	35.24
1.057	liter	quart (liquid), qt.	.946
.333	teaspoon, tsp.	tablespoon, tbsp.	3
.5	fluid ounce	tablespoon, tbsp.	2
.125	fluid ounce	cup	8
29.57	fluid ounce	milliliter, ml	.034
2	pint	cup	.5
16	pint	fluid ounce	.063
	Mass		
1.102	ton (metric)	ton (English)	.907
2.205	kilogram, kg	pound, lb.	.454
.035	gram, g	ounce (avdp.), oz.	28.35
	Yield		
.446	ton (metric) hectare	ton (English)/acre	2.24
.891	kg/ha	lb./acre	1.12
.891	quintal/hectare	hundredweight/acre	1.12
.016	kg/ha-corn, sorghum, rye	bu./A.	62.723
.015	kg/ha-soybean, wheat	bu./A.	67.249
	Temperature		
$(9/5 \cdot C)+32$	Celsius	Fahrenheit	$5/9(F-32)$

Plant Nutrition Conversion

P(phosphorus) $\times$ 2.29 = P_2O_5 $\qquad$ $P_2O_5 \times .44 = P$

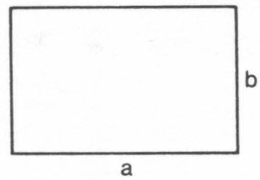
K(potassium) $\times$ 1.2 = K_2O $\qquad$ $K_2O \times .83 = K$

ppm x 2 = lb./A. (assumes that an acre plow depth of 6⅔ inches weighs 2 million pounds)

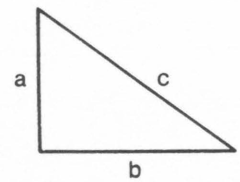
Useful Equations

$$\text{Speed (mph)} = \frac{\text{distance (ft.)} \times 60}{\text{time (seconds)} \times 88}$$

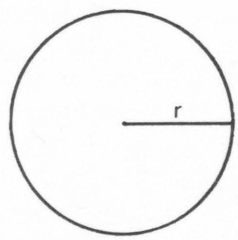
1 mph = 88′/min.



Area = a $\times$ b



Area = ½ (a $\times$ b)



Area = πr^2

$\pi = 3.1416$

$$\text{lb./100 ft.}^2 = \frac{\text{lb./acre}}{435.6}$$

$$\text{Example: 10 tons/acre} = \frac{20{,}000\ \text{lb.}}{435.6} = 46\ \text{lb./100 ft.}^2$$

$$\text{oz./100 ft.}^2 = \frac{\text{lb./acre}}{435.6} \times 16$$

$$\text{Example: 100 lb./acre} = \frac{100}{435.6} \times 16 = 4\ \text{oz./100 ft.}^2$$

$$\text{tsp./100 ft.}^2 = \frac{\text{gal./acre}}{435.6} \times 192$$

$$\text{Example: 1 gal./acre} = \frac{1}{435.6} \times 192 = .44\ \text{tsp./100 ft.}^2$$

Water weight = 8.345 lb./gal.

Acre-inch water = 27,150 gal.